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NATIONAL FIRE PROTECTION ASSOCIATION

Quarterly

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QUARTERLY

of the

NATIONAL FIRE PROTECTION ASSOCIATION

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Roland Oxton

Combustible concealed spaces, without firestopping, are an invitation to destructive fire. This fire, in an old Boston building occupied for paper storage and paper working, reportedly started in a concealed space near a fireplace. According to the Boston Fire Department, the temperature in the building increased too slowly to operate the automatic fire alarm system until fire broke out of the concealed space and flashed through the building at 2:57 A.M., March 9, 1950. Loss: $1,000,000.

The Quarterly

Vol. 43 April, 1950 No. 4

Meeting of Board of Directors

New York, N. Y., January 20, 1950

Present

A. H. S. Stead, Vice-President
Allen L. Cobb, Vice-President
Hovey T. Freeman, Secretary-Treasurer
C. W. Pierce, Past President
Richard E. Vernor, Past President and Acting Chairman

John H. Alderson	John Kidde
A. L. Brown	R. D. MacDaniel
Hylton R. Brown	H. E. Newell
Loren S. Bush	John Neale
T. S. Duke	Geo. J. Richardson
J. E. Frederickson	W. A. Ross

Percy Bugbee, General Manager, Robert S. Moulton, Technical Secretary, Horatio Bond, Chief Engineer, Charles S. Morgan, Assistant to the General Manager.

Business Transacted

1. General Manager Bugbee reported on plans and program for the 1950 annual meeting, and was authorized to proceed along the lines indicated under the direction of the Program Committee.

2. It was voted to confirm tentative arrangements for holding the 1951 annual meeting in Detroit, May 7-10, and the 1952 annual meeting in Montreal, May 12-16. It was further voted to authorize the General Manager to make tentative arrangements for holding the 1953 annual meeting in Chicago.

3. Treasurer Freeman reported on the finances of the Association, indicating a healthy excess of income over expenditures. This report was accepted.

4. Executive Office reports were presented as follows:

(a) Membership—Mr. Bugbee.
(b) Fund Solicitations—Mr. Bugbee.
(c) Pension Plan—Mr. Bugbee.
(d) General Publications—Mr. Moulton.
(e) Fire Inspection Manual—Mr. Bond.
(f) Firemen Magazine—Mr. Morgan.
(g) Advertising—Mr. Morgan.
(h) Electrical Field Service—Mr. Bugbee.
(i) Fire Marshals' Section—Mr. Morgan.
(j) Public Relations Activities—Mr. Bugbee.
(k) Fire Record Department—Mr. Moulton.
(l) Library—Mr. Bugbee.

These reports were discussed and accepted.

5. Regional meetings held in Buffalo, Nov. 1-2, 1949 and Atlanta, Nov. 29-30, 1949, were reported upon and discussed by Messrs. A. L. Cobb, A. L. Brown, Hylton Brown, J. E. Frederickson, Bugbee and Moulton. It was voted to express the appreciation of the Board to members Cobb and Sampson, General Chairmen of the Sponsoring Committees, for the meetings in Buffalo and Atlanta respectively, for their valuable contributions towards successful meetings advancing the objectives of the Association. It was voted to authorize the staff to proceed with plans for holding regional meetings in the Northwest and in the Southwest in the fall of 1950, subject to the completion of satisfactory arrangements.

6. General Manager Bugbee reported subscriptions of $5,000 each from two cigarette manufacturing companies in response to the solicitation of funds for a proposed educational campaign to be conducted through the Advertising Council (see Minute 13, Board of Directors' meeting, July 17, 1949). It was voted to authorize Mr. Bugbee to proceed to request an allocation from the Advertising Council upon securing additional subscriptions of $1,000 or more.

7. Chairman Cobb of the Special Committee on Industrial Fire Problems presented the following report of the committee:

A meeting of this committee was held in Philadelphia at 10:00 A.M. on Friday, November 18th, for the purpose of reviewing the several suggestions which have been received in regard to improving the industrial service of the NFPA and to make recommendations to the Board of Directors.

Following considerable discussion, it was agreed that the present work of the NFPA is largely industrial in character and should be of greater interest to industrial people generally, but that it does not receive the width and form of distribution to those people which it should have for sufficient appeal and that in many instances, industries are not fully aware of the services the Association can offer that are of direct interest and assistance to them.

It was also agreed that the present annual program might be considerably improved in the matter of interest and greater appeal to industrial representatives.

It was agreed, further, that local fire protection gatherings of various types have developed a great deal of interest, not only through Regional Conferences of the NFPA, but through meetings of local industrial fire protection organizations as in the state of Ohio.

It was, therefore, concluded that the following recommendations of this committee should be submitted to the Board of Directors at its January meeting.

1. The Board of Directors should appoint an industrial or manufacturing committee to promote the industrial work of the Association. It should be a representative committee, to the extent of having representatives from diversified industries both large and small, but should not have representatives from insurance, fire protection equipment manufacturers, or regulatory groups.

The new industrial or manufacturing committee should not work on technical standards but should thoroughly investigate: the method of transmitting NFPA material to manufacturing concerns including the form of the information presented, means of arousing greater interest in the Association, aids to securing additional membership from industrial concerns, and the extending of information available from NFPA through the medium of local organizations such as local safety councils, Chambers of Commerce and similar organizations. The new committee should also look into the possibility of developing local associations of persons interested in industrial fire protection.

2. The new manufacturing or industrial committee should review published material of industrial interest and make recommendations regarding improvement where this appears to be desirable. In particular: as standards are rewritten, it is suggested that informational material be added, including illustrations whenever possible and desirable, to better explain their intent and assist their application.

3. It is recommended that the new committee consider the desirability of regular issuance of a small publication of particular interest and direct appeal to industrial members.

4. This committee recommends, further, that one entire day in the annual meeting be devoted to industrial problems and that the program of this day be devoted almost entirely to consideration of up-to-date fire problems of general interest in industry.

Your committee also recommends that any technical reports brought up for consideration and action during the course of this day's meeting should be of direct interest to industry and that the report should be presented in a brief and interesting fashion to describe the background, reasons for changes, and other material of interest.

This report was accepted with appreciation to the committee, and it was voted to authorize the Acting Chairman of the Board to appoint an Industrial Committee of the Association, with personnel and scope statement subject to approval by the Board at a subsequent meeting.

8. Mr. Bond reported on the status of civil defense planning in the United States. This report was accepted with an expression of appreciation to Mr. Bond for his conscientious service in this matter.

9. Mr. Bugbee reported on the retirement of T. Alfred Fleming of the National Board of Fire Underwriters, Chairman of the NFPA Committee on Fire Prevention and Clean-up Campaign. It was agreed that NFPA activity in conducting Fire Prevention Week and in conducting a contest in connection therewith should be continued, and Mr. Bugbee was authorized to proceed with plans to this end, subject to approval by the Board at a subsequent meeting.

10. Mr. Moulton reported on developments in connection with the solicitation of funds for the proposed employment of a Flammable Liquids Field Engineer in accordance with authorization by the Board at its last meeting.

11. Mr. Bugbee reported on developments in connection with the previously authorized plan for citations to members who have rendered distinguished service to the Association. After discussion of this plan, of the possible award of certificates or medals, and of Honorary Life Memberships, it was voted to authorize Mr. Bugbee to proceed with the plan, under the direction of the Advisory Committee, and that the names of candidates for any awards to be made at the 1950 annual meeting be submitted by the Advisory Committee to the Board prior to the annual meeting.

12. A proposal that the Association should intervene in a federal court case involving the constitutionality of fire prevention ordinance provisions based upon NFPA standards was discussed and referred to the Advisory Committee with power.

13. The report of the Committee on Technical Committee Procedure, C. W. Pierce, Chairman, was accepted.

(a) On the grounds of questions raised as to irregularity of procedure in respect to the lack of a complete record of the ballot of the members of the Committee on Protection Against Lightning when this report was presented at the 1949 annual meeting of the Association, and lack of consideration of the views of dissenting members, as reported by the Committee on Technical Committee Procedure, it was voted to suspend promulgation of the revised Code for Protection Against Lightning as adopted at the 1949 annual meeting, and to request the Committee on Protection Against Lightning to consider the views of the dissenting members and report in regular course to the Association at the 1950 annual meeting. It was further voted to appoint John A. Dickinson of the National Bureau of Standards as Secretary of this committee for the purpose of assisting in the clarification of the apparent confusion involved in this case and to assure the presentation of a complete and properly recorded ballot on the report of the committee to be presented to the next annual meeting.

(b) The appointment of a Conference Committee on Industrial Tractors and Lift Trucks, sponsored jointly by the Committees on General Storage, on Storage of Combustible Fibres, and on Piers and Wharves, was approved.

(c) The committee reported on ASA action on NFPA standards as follows:

"We are pleased to report that the American Standards Association approved the 1949 revisions of the National Electrical Code accepting our view that these revisions represented a national consensus appropriate for recognition as American Standard arrived at through a procedure complying with the spirit of ASA provisions although admittedly not fully consistent with all the technical provisions of the ASA rules of procedure. Several NFPA members interested themselves in this matter and rendered valuable service in facilitating ASA action.

"The 1949 edition of the Building Exits Code has been approved by the ASA and action is pending on the approval of the 1949 edition of the Standard on Places of Outdoor Assembly.

"We have submitted the 1949 edition of our Dust Explosion Codes to the ASA in accordance with the usual routine and previous authorization. There is, however, an apparent technical

obstacle to ASA approval. Mr. Eugene Arms represents three organizations on the committee, but he only filed one vote. The ASA office indicates that as representative of three organizations he should have voted three times and that in analyzing the committee personnel he should be counted as three members. Doing so results in having the number of insurance representatives on the committee more than one-third of the total personnel, which is contrary to ASA rules of procedure. We are hopeful that this situation can be straightened out."

14 (a) It was voted to confirm the Board action by letter ballot, completed October 18, 1949, in adopting a revised Recommended Safe Practice for Hospital Operating Rooms, on recommendation of the Committee on Hospital Operating Rooms and the Committee on Gases, as authorized by the Association at the 1949 annual meeting (revised text published by NFPA as Standard No. 56, 1949).

(b) It was voted to confirm the Board action by letter ballot, completed January 17, 1950, in adopting revised Regulations Governing the Control of Gas Hazards on Vessels to Be Repaired on recommendation of the Committee on Gas Hazards and the General Committee on Marine Fire Protection, as authorized by the Association at the 1949 annual meeting (revised text published by NFPA as Standard No. 306, 1949).

(c) Chairman Cobb of the General Committee on Special Extinguishing Methods reported that due to certain questions concerning illustrations and other details of additional appendix material proposed for the Standards on Foam Extinguishing Systems, which the 1949 annual meeting had authorized the Committee on Foam to complete and submit to the Board subject to concurrence by the General Committee on Special Extinguishing Methods, these proposed additions would be revised and submitted to the 1950 annual meeting in regular course, obviating the occasion for action by the Board. Mr. Cobb also reported a plan for interim publication of the Foam Standards already adopted, with tentative appendix material, devised to meet the need for early publication of the revised standards.

15. On recommendation of the Committee on Technical Committee Procedure, it was voted to confirm the various committee appointments authorized by the Board at its last meeting and recorded in the 1949 Year Book, also to confirm the additional committee appointments as submitted to the Board at the meeting.

16 (a) It was voted to instruct the Executive Office to investigate the present status of the Lightning Rod Manufacturers Association and of the National Lightning Protection Association and to report to a subsequent meeting of the Board such facts as may be pertinent to a determination of their continuing eligibility to organization membership in the NFPA.

(b) After discussion of the lack of any provision for termination of membership appearing in the present Articles of Association, it was voted to submit to the Association at the 1950 annual meeting the following proposed amendments to the Articles:

Article 8. Add: "The Board by two-thirds vote may rescind any membership."

Article 3 (b) First sentence, insert the following after the word individuals "interested in the protection of life and property against loss by fire."

$1,000 Contest on Basement Ventilation

Prizes totaling $1,000 are offered NFPA members by Durham and Bates, General Insurance Agents of Portland, Oregon, for the best description of methods to provide ventilation to reduce fire and smoke losses from a basement fire in a typical mercantile store. All Associate NFPA members and employees of member organizations are eligible, except for the judges, members of the NFPA Executive Office staff and employees of Durham and Bates.

Contest Rules

Prizes will be awarded as follows: First Prize, $500; Second Prize, $250; Third Prize, $100, and three Honorable Mention Prizes of $50 each. The prizes will be awarded in accordance with the findings of the judges, whose decision will be final.

The judges are:

JOHN J. AHERN, Director, Dept. of Fire Protection and Safety Engineering, Illinois Institute of Technology; Chairman, NFPA Special Committee on Fire Protection Engineering.

A. H. BAUM, President, Building Officials Conference of America; Building Commissioner, City of St. Louis, Missouri; Chairman, Basic Code Committee, BOAC.

THEODORE I. COE, Technical Secretary, American Institute of Architects; NFPA Committee on Building Construction; Chairman, Building Code Correlating Committee, American Standards Association.

RAY C. CORSON, Engineer, Standards Dept., Factory Mutual Engineering Division; Chairman, NFPA Committee on Building Construction; NFPA Committee on Air Conditioning.

A. J. MULLANEY, Past President, International Association of Fire Chiefs; Chief Fire Marshal, City of Chicago; NFPA Committee on Firemen's Training.

All contestants must submit their answers to the NFPA Executive Office, Attention: Ventilation Contest, 60 Batterymarch Street, Boston 10, Mass., on or before November 1, 1950. Answers must be typewritten on one side of 8½ by 11 in. paper and any drawings or other materials accompanying the text must be folded to 8½ by 11 in. size. Answers must be on plain paper with no information to identify the name or business connection of the author, but each submission should be accompanied by a letter of transmittal giving the author's name and address. Such letters will be detached in the NFPA Office and the papers will be identifiable only by a serial number while being considered by the judges.

Winners of the prizes will be announced at the 55th Annual Meeting of the Association to be held in May 1951 at Detroit, Michigan. All answers submitted, irrespective of whether or not they are prize winners, will become the property of Durham and Bates for such use or publication as they may desire.

There is no limit to the length of the answer submitted, but preference will be given to answers in the shortest form consistent with clear presentation of the information. Contestants should note that the judges are very familiar with the fundamentals of fire protection and ventilation, and that there is no occasion to include detailed descriptions of *standard* fire protection and ventilation equipment of commonly recognized types. Any special methods of fire protection should, however, be completely described.

Description of Purposes

The purpose of this contest is to stimulate thought and to design methods of providing ventilation for a basement of a mercantile store so as to arrest the spread of fire and smoke and to conduct safely from the building heated air masses and fire gases which are normally encountered. Experience has shown that lack of ventilation methods has a profound influence on the spread of fire in a building, on the amount of contingent smoke damage, on the danger of panic in occupied structures, and on the hazards of explosion or "backdrafts" which endanger the lives of occupants and fire fighters.

The need for basement ventilation of mercantile stores has been most evident from the fire record of this class of occupancy for years. In a special NFPA study of 6,209 fires in stores during the period 1930-1946,* it was found that 42.7% originated in basements.

Typical Situation

In order to assure that contestants have a correct understanding of the problem, the following description is offered of a typical store:

OCCUPANCY: Dry goods store.

HEIGHT: Two stories and basement.

GROUND FLOOR AREA: 10,000 sq. ft.

WALL CONSTRUCTION: Brick, with basement entirely below ground level, all sides of structure. Show windows at street front first floor with plate glass. Ordinary glass windows second floor front and rear. Windows on first floor rear covered with heavy wire-mesh screen. Foundations of concrete with no openings. Walls are firestopped.

FLOOR CONSTRUCTION: Basement floor: concrete; first floor: terrazzo over wood sub-floor on open wood joist; second floor: linoleum over hardwood floor on wood joist, first and second floor ceilings metal directly fastened to wood joist.

ROOF CONSTRUCTION: Flat deck wood roof on wood joist with tar and gravel finish.

VERTICAL OPENINGS: One stairwell, basement to first floor (only personnel entrance) in rear center of store, enclosed by one inch wood partitions on two-inch by four-inch studs with single untreated panel door at head of stairs. Another unenclosed central stairway in center front of building, first to second floor. A third enclosed stairway at rear left corner of structure first to second floors, with Class C fire doors on interior opening into stairway. Exit from this stairway direct to street and parking area to rear.

HORIZONTAL DIVISION: None except around rear stairwell as indicated above; otherwise one large area structure.

HEATING EQUIPMENT: Oil burner located at rear of building in basement with oil storage tank buried underground outside basement wall in parking lot. Wood frame enclosure with no door to oil burner room.

EXPOSURES: Front of building on main downtown street 60 ft. wide; back of building open to parking lot of similar 60 ft. width; both sides of building adjoining other stores with fire wall parapeted to standard height so that these exposures can be discounted as far as normal potential fire spread horizontally is concerned.

EXITS AND ENTRANCES: No basement entrance from outside the building except freight elevator on front sidewalk with metal cover, barred from inside. Sole personnel entrance to basement being from interior single stairwell. Adequate exits and entrances at ground level from front and rear with panic-proof hardware at exit from corner stairway.

CONTENTS: Entire basement used for storage of commodities common to the operation of average dry goods store. Open pine shelving for storage of small commodities in bulk with considerable additional storage of paper boxed materials and goods. Large closet (20 ft. by 20 ft.) for janitor's supplies but no flammable liquids. No special hazards, other than oil burner, in basement but a large amount of combustible materials. First and second floors, retail store outlet with usual counters and display cases, dressing rooms, customer and employee toilet facilities, etc.

*See NFPA pamphlet, "Must Stores Burn?", available from the NFPA Executive Office ($1.00 per copy).

Type of Answer Desired

The type of answers which this contest seeks to secure are methods to provide, *prior to a possible basement fire in this building*, adequate basement ventilation to prevent fire from doing excessive fire or smoke damage to the first and upper floors. For the purposes of this contest, the provision of automatic fire *extinguishing* equipment will *not* constitute the *sole* answer. The principal object is to encourage development of ventilation methods through the use of mechanical equipment in a manner which will not result in spread of fire and for the purpose of reducing the extent of damage to the occupancy. This includes automatic means of ventilation in event of fire and methods which might be followed by fire fighters called to the scene. It may be assumed that detection of the hypothetical fire, which we assume will occur for the purposes of the contest, in the basement of this building, will be 15 minutes *prior* to penetration of flame through the wood enclosed basement stairwell, but *after* the entire basement is choked with smoke.

The Question

How would you provide basement ventilation that would enhance the fire safety of this building? Your answer may win you $500, courtesy of Durham and Bates!

New Fire Extinguishing Agents for Aircraft*

By Howard A. Klein, Engineering Division, Air Materiel Command, U. S. Air Force

EDITOR'S NOTE

In 1944 the Equipment Laboratory of the Air Materiel Command, United States Air Force, was directed to continue an existing development program on aircraft fire prevention and protection with the assistance of all available agencies. The program has a seven point attack on the aircraft fire problem, namely:

1. Determine causes of aircraft fires.
2. Determine means of preventing aircraft fires.
3. Determine means of extinguishing aircraft fires.
4. Design and test equipment for aircraft fire extinguishing systems.
5. Design and test hand extinguishers for all aircraft requirements.
6. Determine detail design of all aircraft installations.
7. Design and test aircraft fire detection equipment and warning devices.

Mr. Klein reported the progress on this program to the NFPA Committee on Aviation and Airport Fire Protection at its meeting in Indianapolis on March 1-2, 1950, and a complete transcript of his talk has been published in Aviation Committee Bulletin No. 44.*

New Extinguishing Agents — Aircraft Powerplants

The earliest fire extinguishing agent used in military aircraft was carbon tetrachloride. About 1926 CO_2 first made its appearance and soon replaced carbon tetrachloride in fixed systems. The extensive use of CO_2 was helped in no small measure by its relative inexpensiveness due to its volume production as a refrigerant and carbonating agent.

As early as 1929 tests in this country proved the effectiveness of methyl bromide, however, no progress toward its use

*Extract from a paper presented at a meeting of the NFPA Committee on Aviation and Airport Fire Protection held in Indianapolis, Ind., March 1-2, 1950. Complete text published in Aviation Committee Bulletin No. 44, available from the NFPA at $1.00 per copy.

in this country was made until 1939 when the CAA tests† emphasized its effectiveness. The major drawback to its use in this country appears to be what I class as overemphasis of its toxic effects which have literally scared it out of use. Methyl bromide is more toxic than carbon tetrachloride or carbon dioxide, however, because of its exceedingly fine fire extinguishing properties, smaller quantities are required. In addition, in use in aircraft, exposure would normally be in open air and for durations seldom more than 1 minute. The British, on the other hand, having less regard for its toxic properties, have used methyl bromide for several years, and as early as 1938 adopted it as standard and have not experienced an undue mortality rate.

Early in the war (presumably around 1939) the Germans entered into the study of fire protection systems by running a series of contests, sponsored by the German Air Minister. Design and samples were selected from the contestants and allocated to three different companies for experimentation. Under this contest the German Navy adapted an agent referred to as CB. This agent consisted of: 82% bromochloromethane; 9% methylene chloride; 9% methylene bromide. For use in German aircraft, however, 35% CO_2 was added to CB to produce a dachlaurin or DL system. This system was standardized and ordered installed on all German military aircraft in 1945, however, time did not permit its actual installation before the end of the war.

Before going further into the current development of agents I think it best to briefly summarize the major deficiencies for aircraft purposes of those currently in use:

1. Carbon tetrachloride possesses rather poor fire extinguishing properties and, under certain conditions, formulates dense black smoke and produces toxic decomposition products, including traces of phosgene.

2. Carbon dioxide possesses poor low temperature characteristics, poor extinguishing properties, and, being a high vapor pressure agent, requires a heavy high pressure system. A fact often overlooked is that only about 70% of a CO_2 aircraft system charge can be effectively discharged for fire extinguishing purpose.

3. Methyl bromide is highly toxic and extremely corrosive. At normal temperature it is a gas and this requires a closed system for charging containers.

Bromochloromethane, by contrast, appears to be much more satisfactory. It is a liquid at room temperature with a freezing point well below –100°F. It is less toxic than carbon tetrachloride or methyl bromide and is approximately equal to methyl bromide in fire extinguishing ability. It is, of course, much more effective than carbon tetrachloride or CO_2. DL as used by the Germans is much more effective than plain CB, however, due to its high vapor pressure the weight of an overall system is greater. Bromochloromethane, as manufactured and tested in this country, is 98% pure and has proved to be as effective as claimed. As a result of information obtained from Germany and extensive tests conducted in this country, proposed revisions to current USAF specifications on aircraft fixed fire extinguishing systems require the use of bromochloromethane for future installations. It is

†See Technical Development Notes No. 33, No. 37, and No. 38, "Determination of Means to Safeguard Aircraft from Powerplant Fires in Flight," available from the Civil Aeronautics Administration, U. S. Department of Commerce, Washington 25, D. C., Attn.: Aviation Information.

also proposed to replace the agent in present methyl bromide systems with CB as soon as the present supply of methyl bromide is exhausted.

Although bromochloromethane has many advantages over the common agents, the Air Materiel Command in the interest of continuously developing a safer aircraft, began about two years ago an extensive agent development program for a superior fire extinguishing agent. The properties of such an agent should be:

1. better extinguishing properties than bromochloromethane over the temperature range of –65°F. to +160°F.
2. less toxic than bromochloromethane
3. less corrosive than bromochloromethane
4. suitable for class A, B and C fires
5. higher specific gravity than bromochloromethane

For the most part these requirements are self-evident. The desirability of a higher specific gravity agent becomes apparent when consideration is given to the fact that such a new agent may make it possible to add several more pounds of agent in existing bottles and at existing fill ratios or a new agent may result in smaller bottles with fire extinguishing ability equal to the present bottles. Since the use of space and weight is critical in aircraft, the system yielding the most agent per given system weight and volume is the desired system.

With the required properties in mind, the Air Materiel Command began to proceed on its own until it was found that other Government agencies were interested in a similar problem. We found that the Corps of Engineers had begun a research program at Purdue University. To avoid duplication of effort the AMC entered into a joint program with the Corps of Engineers to expedite and accelerate their program. Approximately one hundred agents and inert gases were screened, many by means of a Bureau of Mines apparatus for determining flammability peaks by the upward flame propagation method. The "peak" is the minimum volumetric concentration of agent to produce an atmosphere incapable of sustaining combustion regardless of the concentration of combustible in air. Included in the survey were halogenated saturated and unsaturated hydrocarbons, for the most part limited to from one to three carbon atoms. Availability and economic considerations have automatically excluded iodine from practical considerations, although some iodine compounds were evaluated primarily for their theoretical value. An analysis of results indicates that agent effectiveness decreases from iodine to the bromine to the chlorine and finally to the fluorine derivatives of a given homologons series of agents. Toxicity also follows the same pattern with iodine derivatives most toxic while fluorine derivatives are least toxic. In general, chemical stability also follows a similar pattern.

To combine the desirable features of a superior agent containing good nontoxicity features it was concluded that the bromofluoro compounds may be most desirable after due consideration to all factors involved.

The table at top of page 238 contains the percent peak of flammability for some of the superior bromofluoro compounds as compared to conventional agents.

The Halon numbers are Corps of Engineers nomenclature for halongated hydrocarbons. Reading from left to right, the first digit indicates the number of carbon atoms, the second the number of fluorine atoms, the third the number of chlorine atoms and the fourth the number

Table Showing Percent "Peak of Flammability" for New and Conventional Agents

Agent	Formula	Halon No.	% Peak of Flammability	Order of Effectiveness Vol.	Wt.
Dibromodifluoromethane	CBr_2F_2	1202	4.2	1	2
Bromotrifluoropropane	$CF_3CHBrCH_3$	3301	4.9	2	1
Dibromotetrafluoroethane	$CBrF_2CBrF_2$	2402	4.9	3	6
Bromotrifluoromethane	$CBrF_3$	1301	6.1	4	3
Bromochloromethane	CH_2BrCl	1011	7.6	5	5
Methyl bromide	CH_3Br	1001	9.7	6	4
Carbon tetrachloride	CCl_4	104	11.5	7	8
Carbon dioxide	CO_2	...	29.5	8	7

of bromine atoms. The fifth number would indicate the number of iodine atoms, but all terminal zeros are omitted so that in the case of the bromofluoro compounds only four digits are used.

It becomes readily apparent that experimental agents, on a laboratory scale appear to surpass the standard agent in fire fighting effectiveness.

Halon 3301 ($CF_3CHBrCH_3$) was deleted from possible practical consideration for economic reasons in view of the fact that Halons 1202 (CBr_2F_2), 1301 ($CBrF_3$) and 2402 ($CBrF_2CBrF_2$) are likewise superior to standard agents (on the flammability basis). The latter three Halons were then tested on actual fires. At normal temperatures they were superior to the standard agents. However, in initial tests superiority among them could not be established. They all appeared approximately equal. Low temperature tests from –50 to –65°F., however, indicate that Halon 1301 ($CBrF_3$) and 1202 (CBr_2F_2) were vastly superior to methyl bromide and Halon 2402 ($CBrF_2CBrF_2$). Halon 1301 had a very slight edge over 1202. Methyl bromide had an edge over 2402.

The process of elimination finally resulted in tentatively choosing Halon 1202 (CBr_2F_2) for USAF requirements for aircraft protection. Halon 1301 ($CBrF_3$) was discarded because it is a high pressure gas at room temperature (240 psig at 70°F). At –65°F. it possesses only 5 psig pressure. Obviously this agent would still have to be pressurized with nitrogen to obtain satisfactory discharge at –65°F. At 160°F. a 50% fill would result in a pressure of 760 psi plus the pressure of the pressurizing gas required at –65°. Thus the system would result in a heavy pressure system analogous to carbon dioxide systems. Aircraft portable extinguishers heavier than the present Type A-20 would also be required. In addition a gas would not accomplish the desired results for USAF Class A fire protection.

Preliminary toxicological studies were being performed concurrently with the evaluation of Halons 1202 (CBr_2F_2), 1301 ($CBrF_3$) and 2402 ($CBrF_2CBrF_2$). This phase of the study is being performed at the Army Chemical Center at Edgewood, Maryland. The table below indicates an average lethal concentration for rates in parts per million for the experimental agents as compared to the standard agents.

Agent	Average Lethal Concentration 15 Min. Exposure Parts per million
Carbon tetrachloride (CCl_4)	28,600
Bromochloromethane (CH_2BrCl)	57,300
Methyl bromide (CH_3Br)	2,900
Carbon dioxide (CO_2)	667,200
Halon 1301 ($CBrF_3$)	933,300
Halon 1202 (CBr_2F_2)	74,100
Halon 2402 ($CBrF_2CBrF_2$)	131,600

This table indicates that the experimental agents are superior to the standard agents with regard to toxicity with one exception, carbon dioxide.

Pending full toxicity data, Halon 1202 (CBr_2F_2) appears to possess the superior qualities required of a USAF aircraft fire extinguishing agent, in spite of the better toxicity properties of Halon 1301 ($CBrF_3$).

Portable Aircraft Extinguishers

It was found desirable to develop a new hand fire extinguisher for combatting incipient in-flight fires in aircraft. Equipment used in the past consisted of both 1 quart pump type carbon tetrachloride and 2.65 lbs. carbon dioxide extinguishers. Both of these extinguishers are unsatisfactory — the carbon tetrachloride extinguisher because of the toxicity of its products of decomposition and because of unsatisfactory performance of the pump mechanism; the carbon dioxide because of erratic operation at –65°F. and its relative ineffectiveness on class A fires.

The following items were considered at the inception of this development:

(1) Effective in extinguishing class A, B and C fires.

(2) Satisfactory operation for –65° to +160°F.

(3) Ease of operation, *i.e.*, capable of being operated with one hand while wearing winter flying gloves.

(4) Relatively non-toxic products of decomposition of the agent.

(5) Compact size and light weight.

(6) Ease of maintenance and recharging.

It was decided that bromochloromethane was the best available agent for this purpose and that it could be expelled by means of a cartridge punctured at the time of discharge. Two development contracts were awarded for extinguishers of this type, however, it was found that a cartridge to provide sufficient pressure to expel the agent at –65°F. was a major problem. One of the extinguishers submitted utilized two small winterized CO_2 cartridges, punctured simultaneously, however, there was not enough pressure to expel the agent in the required length of time. The other extinguisher submitted utilized a large nitrogen cartridge. The capacity of this cartridge was sufficient to meet performance requirements, however, it made the extinguisher bulky and heavy.

As a result of the experience gained in these developments, a decision was made to use a stored pressure type extinguisher where the agent is under a constant pressure of 150 psi of air. A tentative specification was prepared which specified the desired performance of the unit and specified certain dimensions required for interchangability.

This specification has recently been released and a great deal of interest has been expressed in this extinguisher by industry. To date, three extinguisher manufacturers have submitted samples for qualification tests, and at least one other is working on a design.

Basically, the extinguisher has the following characteristics:

(1) It contains 1 quart of bromochloromethane under a stored pressure of 150 psi at 70°F.

(2) It has a horizontal range of 20 feet and at least a 25-second duration of discharge at 70°F.

(3) It can be operated with one hand, and it incorporates a temporary shut-off.

(4) Recharging is accomplished by means of removal of the entire valve or by removing a filler plug. It is pressurized by applying a standard air chuck to the nozzle.

(5) It incorporates a pressure gage to provide a quick visual check as to the status of the contents.

(6) It is suitable for operation under all environmental conditions.

(7) It is 3 inches in diameter and approximately 15 inches in over-all height.

(8) It weighs approximately 7 pounds.
(9) It is provided with a quick release bracket.

Toxicity data available to the Air Materiel Command indicates that the products of decomposition of bromochloromethane are considerably less toxic than those of carbon tetrachloride. Also, tests conducted by this Command indicate that bromochloromethane is three times more effective than carbon tetrachloride, thereby reducing the quantity of agent, which needs to be discharged on the fire.

This extinguisher, designated as the Type A-20, will be installed in new aircraft in the following quantities:

(1) One extinguisher in each crew compartment of multi-place aircraft.

(2) One extinguisher at each end of the cargo compartment in transport aircraft, except when the compartment exceeds 50 feet in length two extinguishers shall be installed at each end of the compartment.

Conclusion

The development of fire protection equipment for aircraft has been held back because of lack of personnel and facilities and at present development is far behind aircraft requirements. Lack of personnel has made it impossible to monitor aircraft fire prevention requirements or to properly test new equipment and agents.

Causes and Prevention of Cotton Fires†

By Mathew M. Braidech and Robert C. Dean
Research Division, National Board of Fire Underwriters

The dominant position of cotton in our economy and the magnitude of fire losses in processing and storage operations in recent years have caused fire insurance underwriters and fire protection engineers to look upon the cotton fire problem with much concern. In one record-breaking season, 1945-46, some 600 individual fires, not including hundreds of small losses, were reported by the insurance groups. These involved an all-time high of almost 100,000 bales, or an economic loss of nearly $15,000,000. The fire-damaged ginning plants represented another $2,000,000 loss in property. Graphically, this represents the equivalent destruction of the output of nearly 200,000 acres of productive farm land — truly a wanton waste of one of our most important natural resources! Table No. 1 shows the insurance loss experience for the past four years.

To assist in the control and reduction of these serious cotton fire losses, the National Board of Fire Underwriters assigned its Research Division the task of conducting an over-all exploratory investigation.

A field survey was conducted during the peak ginning periods of the 1948 and 1949 seasons. The 1948 program included Tennessee-Georgia-Mississippi-Arkansas-East Texas territory of the Eastern cotton belt, while the 1949 itinerary covered the West Texas-New Mexico-California (San Joaquin Valley) district of the Western cotton belt. Some 50 gins, compress and warehouse sites, yard storage areas, and shipping centers were visited. Conferences were also held at a cotton ginning laboratory and a field station of the U. S. Department of Agriculture.

†Extracts from paper presented at the Southeastern Conference of the National Fire Protection Association, Atlanta, Georgia, November 29, 1949.

Table No. 1

Season	Seasonal Risk in Bales: Production (Carryover)	Seasonal Risk in Bales: Total Risk	Reported Fire Loss Record in Bales: Fire Damaged (Water Damaged)	Reported Fire Loss Record in Bales: Total Loss**
1945/46	8,972,000	20,012,000	56,797	90,884***
	(11,040,000)		(25,518)	(82,315)
1946/47	8,582,000	15,755,000	17,314	26,400
	(7,173,000)		(9,086)	
1947/48	11,542,000	14,069,927	26,911	34,891
	(2,521,000)		(7,890)	
1948/49	14,868,000*	20,151,000	38,729	52,867
	(5,283,000)		(14,138)	

*Largest yield since 1937, when 18,252,000 bales were ginned. The production during the last ten years averaged 11,306,000 bales.

**Average value of $150/500-lb. bale — 1949 losses, up to August 25, 1949, amounted to nearly $8,000,000, an increase of 54% over previous season.

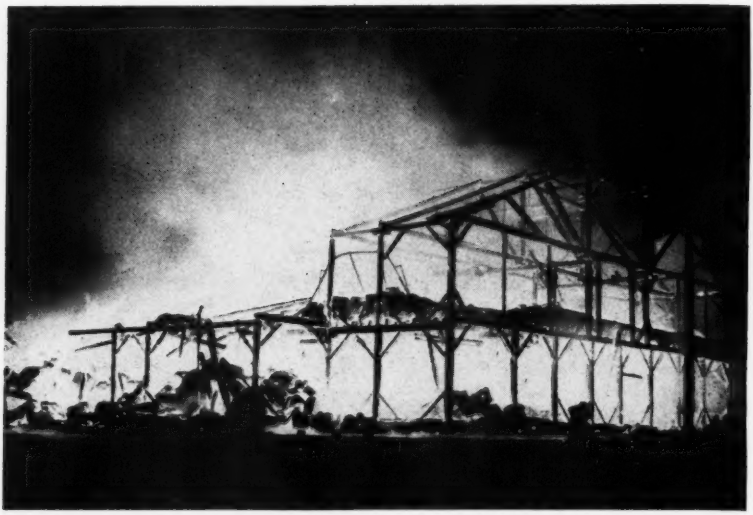
***This final total figure not broken down.

Various contrasting practices and techniques of fire prevention and fire protection were noted in the different territories. A good number of these appeared to be governed to some extent by regional attitudes; others, in the minor category, were in the nature of hearsay abstractions and conjectures built on combinations of fact and fancy.

The seemingly unabated frequency of cotton fires provided a background of realism on several occasions. The engineers of the research staff were given a number of on-the-scene opportunities to view actual fires and fire-damage properties and storage areas. These included a number of seed-cotton trailers found afire in the process of weighing at gin yard en-

Wide World

A fire-packed bale was the probable cause of fire that destroyed 3,182 bales of cotton at Seymour, Texas, October 21. The watchman kept smelling the burning bale, but mistook the odor for that of burning hulls at a near-by gin. The loss was $659,000.



Fire broke out on the second floor of this cotton warehouse in Pinedale, Calif., during the night of January 23. The wet pipe sprinkler system had been drained to prevent freezing. The watchman was not properly instructed. The loss: $1,100,000.

trances. Five instances were observed where so-called fire-packed bales were found smoldering in restricted or quarantine areas. A burned-out seed-cotton storage shed, a gutted and smoking remains of a gin destroyed by a fire (during a shutdown for meals) a day or two prior to the visit, and a public storage yard fire, the prompt discovery and quick exinguishment of which with a new pressurized "wet water" mobile tank forestalled a major loss, were also encountered. Two large-scale fires involving sizable compress-warehouse installations resulted in the loss of 2500 bales with an estimated salvage of only 25% in the one case, and practically a total loss of 3500 bales in the second. The causes were to be reported as "unknown" in both cases. These unscheduled and unfortunate events on the itinerary of inspections served to emphasize the disastrous and costly character of cotton fires, the need for a complete understanding of their causes and the application of suitable corrective and preventative measures.

Contributory Causes of Fire

In presenting this compilation of observations and opinions, it must be stated that there is much divided thought on some of the items and therefore only a general qualitative discussion is given. The possible causes of cotton bale fires are therefore listed and described as follows:

Smoking and Carelessness With Matches

Carefree smoking around gins and yards was observed on a number of occasions. Such utter carelessness was indulged in one case by none other than the gin manager of one of the newest and most modern gins in the West. Standing within a few inches of a "NO SMOKING" sign, he pointed indifferently to

some charred cotton scattered about the ground of the receiving area, giving evidence of an earlier near miss trailer fire, and stated that it was due to matches. In another plant, a ginner was found sitting atop a gin bale, unconcernedly smoking a cigarette within a few feet of the press box which was in his responsible charge.

In California, buried matches in picked cotton are believed to be the principal cause of fires. The indifference and careless habits of transient Mexican labor with "strike-anywhere" matches appear as the major contributing factor. This is contrary to opinions given in other areas and to the tests conducted by the government authorities a good many years ago. Nevertheless, many of the gin owners are making a serious effort to control this situation by free distribution of safety matches. It is felt that this problem will only reach complete control if the supply stores in the cotton territories cooperate by removing from sale the more dangerous matches during the harvest period.

Yard Management and Housekeeping

The common scene of extreme congestion and disorderly crowding of seed-cotton trailers (50 to 90 in number — each load equivalent to 2-4 bales) in gin yards, along with loose cotton and lint strewn around the premises is certain to give any fire safety-minded person the jitters. Combination of warm weather and early ripening of a new strain of cotton has been known to bring a harvest to an early climax. Such an abnormally large crop was experienced this past season in the San Joaquin Valley. The gins were heavily overtaxed and many operators were forced to pile picked cotton on the ground for temporary storage. Exposure of large masses of open and loose cotton presents considerable danger of a quick-spreading flash fire. The indiscriminate parking of loaded trailers without regard to possible emergencies presents a crying need for a yard traffic system.

Gin yard congested with trailer loads of seed-cotton. Note proximity to open storage of processed gin bales in foreground.

The operating conditions found among some of the poorly supervised plants would tend to place the industry in the category of "dusty trades." Not only have their interiors been found littered and draped with hanging festoons of fluffy waste fibers but also the exterior surroundings, including telephone wires, grass, weeds and general vegetation were also found heavily covered with cotton lint, producing a "snow storm" appearance.

Smoking violations and careless burning of burr cleanings and refuse in unapproved trash burners or incinerators present extreme fire hazards, and are threatening "triggers" for sweeping and uncontrollable fires, particularly in windy regions.

Prevalent Causes of Process Fires

Fires in gins may either be large enough to burn actively within the gin, possibly destroying it, or they may be so small and unnoticeable that sparks or small locks of glowing cotton may pass completely through the gin into the press box, and thus into the bale. Such entrapment of fire within a bale will persist in smoldering combustion and continue undiscovered

as a deep-seated burrowing fire, only to burst into a flame as it reaches the outside atmospheric oxygen several days or weeks later in a warehouse, railroad car, or ship's hold. Fires in the ginning process may be created by a wide variety of conditions, such as: matches in the delivered seed-cotton; metallic and other extraneous spark-causing debris; machine failure due to misalignment of moving parts or overheated bearings; feeding of off-grade raw stock; overloading and jamming; and even static electricity. Because of their relative importance to the production of fire-packed bales and their increasing occurrence in all cotton areas, these factors are given separate and detailed consideration, as follows:

Spark Ignition by Extraneous Materials

An amazing variety of foreign matter, such as nails, can openers, bottle caps, keys, bolts, screws, stones, or pieces of wire from fencing and trailer screening have been found drawn with the mass of cotton into the suction pipe at the unloading point and carried into boll breakers and the overhead extractor and cleaner equipment of the gin. Dislodged chunks of rust from old and worn equipment and broken machine parts resulting from improper maintenance also contribute to this hazard. Speed rotating parts of such machinery will readily result in sparking and ignition of the fluffed cotton. Proper arrangement of pre-cleaners and incorporation of magnetic separators at appropriate locations should materially minimize this difficulty.

An extinguished fire-packed bale. Ties removed for salvage after fire was put out. Note charred interior.

Ignition by Excessive Friction in Gin Saws

There is opinion in some quarters that overfeeding will result in load-jamming and the creation of friction burns in the ginned cotton. It is believed that automatic feed regulators, roll density indicators, and general slowing down of the gin machinery will tend to decrease the frequency of fire-packed bales in many gins. Rib-friction fires are known to also develop from dull and out-of-line saws. Improper adjustment of the cleaner brushes for saws may lead to a dragging effect and an eventual build-up of lint stock between the ribs and the saws These last two difficulties are primarily due to poor operation control and improper inspection and maintenance. Dew-laden or rain-soaked cotton, when improperly dried, may tend to hang on the ribs and accumulate on the saw teeth. A so-called "mote-friction and back-pressure" theory was advanced by one of the leading ginners as another cause of friction fires. A "mote" is an unmatured seed, presumably predominant in green or incompletely ripened bolls, small enough to pass through the ribs, or it may be a full-sized seed which has been cut by the gin saws. It is either sticky or fuzzy from its own linters, or both, and if it sticks anywhere, it may pick up an accumulation of lint which builds up against the saws. This

may create enough friction to ignite some lint or even to throw the saw out of alignment against the ribs, causing a hot steel spark. In the case of the "back-pressure" effects, the "mote" forms a matted particle just beyond the ribs. This particle may be too dense for the air-suction blast or brushes to doff easily or to be thrown in the correct direction of discharge.

According to some operators, such a small matter as the wrong setting of a deflecting mote board or a blast of wind directed against the condenser air discharge may result in a backlash of balled lint and cause all sorts of process upsets which can eventually lead to friction fires. Ginners in the West Texas area reported that the roughly harvested seed cotton, which is gathered late in the season in their locality by "stripping," contains a great deal of leaf and stem trash, hulls, large stalks, grass and even soil, which may result in a serious carry-over of such extraneous dirt to the gin saws unless additional pre-cleaning equipment is employed. As much as 4000 lbs. of raw pickings, containing 2000 lbs. of soil, are required to produce a 500-lb. bale, as compared to the nominal 1300 to 1500 lbs. of clean seed-cotton. Excessive trash may also be encountered from mechanical pickers, particularly if the defoliation treatment is not completely successful.

Electrostatic Influences in Gin Fires

Static discharges in the gin are considered to be a major source of trouble, particularly in the southwestern half of the cotton belt, where low humidity and high winds are common. In contradiction to other opinions, this type of gin fire hazard is actually scoffed at by many persons throughout the East and lowland regions having high humidity, notwithstanding the fact that some years ago the Department of Agriculture showed definitely that both seed-cotton and lint-cotton can be ignited by a continuous procession of static spark discharges. When viewed with technical impartiality, the cotton gin appears to be an ideal setup for the generation of electrostatic charges. It is somewhat similar in this respect to a paper-making machine, exhibiting so much in the way of high-speed frictional rolling, sudden separation of bodies, and counter-rubbing movement in the presence of a high velocity air-blast. Some observations by Underwriters' Laboratories in 1939 showed that a voltage of 5000 could be produced by comparatively small amounts of cotton lint in dry air, with an air stream flow of 26 to 39 ft./sec. Because of unusually dry weather and "droughty" cotton in West Texas, electrostatic charges are known to be abundant and troublesome in all metallic parts of the gin.

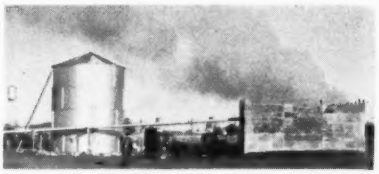
To minimize the static hazard, all joints of metal parts and ducts should be electrically bonded and the entire system grounded. (See National Electrical Code, Sec. 250 on Grounding of Conductors; National Bureau of Standards, Circular C-438, Static Electricity, June 1942; NFPA pamphlet No. 77 on Static Electricity, 1947.)

Even in the absence of sufficient voltage to cause sparks other troublesome effects have been reported. One observation indicated that the static charges gained in the huller, cleaner and feeder seem to cause the lint to become electrically attractive and so cohesive that it subsequently clots in the flues and occasionally mats and chokes the gin saws and starts frictional fires. Because of electrostatic attraction, trash and dirt particles also tend to

cling strongly to the mass of cotton, and being difficult to remove by the usual cleaning operations, the extraneous material drags over between the saws and ribs to add to the trouble of rib fires. Control of static is being attempted in some areas by localized humidification through spray application of "wet water" in advance of ginning to promote surface conductance with moisture films and effect static leakage from the fibers to the grounded equipment. This treatment was introduced originally for moisture restoration (7 to 8% water is allowable) in the ginned cotton and is applied in the lint flue as the cotton enters the press box for bailing. Other possible procedures for static control, which may find application to this cotton problem, include atmospheric grounding by ionization with ultraviolet radiation or the use of radioactive isotopes now becoming available for such purposes through atomic energy developments.

Operation of Drying Systems

Direct-fired drying systems, now almost universally used in ginning operations, have long been suspected by some groups as being a possible source of gin fires, but as far as is known, no fires can be definitely traced to them. These units are intended to be operated at temperatures not exceeding 160°F., yet the first-hand field reports indicated operations at temperatures as high as 225-250°F., and in one instance as high as 360° F. for a short period of time. Change-over from natural gas to LP-gas or fuel oil has resulted in the increase of the length of the flame to a serious extent. Clogging of heater screens with linters may result in material reduc-



Open-pit burr burner found in West Texas. High exposure hazard to gin yard due to pick-up and scattering of glowing embers by wind.

tion of air and cause hazards of incomplete combustion. Possible passage of large combustible particles through the burner space into the cotton being processed should be considered and guarded against, particularly in windy regions. Improper installation of flues and vents may present a serious explosion hazard. Safety provisions require that they terminate outside of the building.

Waste Disposal Burners and Incinerators

Because of the nature of cotton harvesting conducted in Texas appreciable quantities of leaf, hull and stem trash must be disposed of. The most prevalent method here is by burning in various devices ranging from open pits to specially designed incinerators. High winds are commonly encountered in this section of the country and scattering of smoldering firebrands presents a constant threat to the gins and near-by storage yards. Incentives arising from the sale of the ash for its potash content and local community interest in smoke and smog control are resulting in the development of various types of stack-equipped furnaces and screened-top incinerators, and a number of these have already won recognition by insurance engineers. In West Texas, many of the so-called "burr-burners" are still in the process of development. One or two types of waste burners in California employ cyclone separators, with assisted combustion

Specially designed refuse incinerators found in California. Note cyclone separator for improvement of combustion, and spark-protective screen at top of stack.

by secondary fuels, to effect complete incineration. An illustration of one such incinerator with a cyclone separator and spark protective screen is shown in the photograph above.

Fire-packed Bales

Fire experiences in storage and transportation operations appear to direct attention to the following categories: the insidious fire-packed bale, exhausts of loading tractors and trucks, sparks from locomotives, and the breakage of bale tiebands. The careless trespasser and smoker also are factors in storage yards and warehousing and shipment areas. Gasoline-operated tractors and fork-trucks continue to appear in increasing numbers in many large-volume handling centers. The "spark-proof" condenser type of water muffler is being employed as a safeguard. Other improvements to be incorporated into units intended for such hazardous locations include the use of a float-controlled ignition shut-off to insure the presence of correct water levels in such mufflers, and a locked, tamper-proof, fuel tank cap to prevent fueling at any location except at tanks in designated safe areas. Incorporated into this design are a fill-and-vent breather seal, a metal sediment bowl in the fuel line, and fuel pumps to replace gravity feed.

Truck and Box Car Hazards

Shipment of cotton bales is subject to three types of transportation; on open trailer-trucks, in railroad freight cars, and in ships' holds. Trailer trucks are coming into wide use in certain parts of the cotton belt to haul gin bales to compresses and concentration points. Some of these are large enough to carry a load of 90 bales or more on a double trailer arrangement. In some areas Diesel-powered trucks have been found in use, and some suspicion should be directed at the proximity of their vertical mufflers and exhausts to the bales. These bales are not covered nor are they secured tightly to the platform. As a result the bales are subject to a considerable amount of exposure and joggling.

A great many fires have occurred in freight car transportation. The causes are difficult to establish, blame often being placed on fire-packed bales or on frictional heat created by rubbing together of bale bands, or contact with metal structures of the car, nails and other protruding metal fastenings from previous cargo. The increased jostling, swaying, and harmonic vibrations encountered in the present-day high-speed rail transportation will accentuate this problem. The close confinement will also tend to prevent dissipation of the frictional heat generated under the

Examples of bale-tie failure. Fan-head bale in foreground is especially hazardous in promoting spread of fire.

above conditions. Over one-half of the box car fires are believed to have originated from bale band friction. Secure "locking" of the freight cargo, to withstand rough movement on rails should help materially to prevent such fires.

Bale-ties and Buckles

It is possible that some of the otherwise inexplicable fires may be caused by sparks resulting from sudden failure or breaking of bale bands. According to some cotton men, the sound of a snapping band is a familiar one around a warehouse and during loading of box cars. In the usual close quarters of storage the possibility of a breaking band striking another or striking a pipe or concrete pillar suggests a potential spark-ignition hazard. Recent reports from the field indicate that the metal ties are not up to standard, they appear to be too stiff and not so flexible, and more seem to be breaking than usual. One storage yard stated that they were experiencing 15 to 30 "mushroomed" or "fan-head" bales from band failures, involving from 1 to 3 ties, each day on shipments of 1800 to 2000 bales. Another observed that the ties burst explosively within 15 to 20 minutes when 2 bales were involved in a fire, causing a loose mass of lint to be scattered and spreading the fire to 17 other bales with similar band snapping experience. At another location, the 500-lb. bales were being pushed and dropped onto a concrete pavement at appreciable heights from trailers with triple-tiered loads to cause 2 to 4 foot rebounds. Considerable band damage (peculiarly characteristic cutting and shearing at the buckles) was noted with this careless practice.

It appears that no definite specifications exist for these tie-bands. In 1947, most of the bale ties in the West were asphalt coated to prevent corrosion and staining of the cotton and to act as a "pad" to cushion the striking steel and prevent sparks. The coating tended to come off the ties and damaged the cotton at points of contact to cause considerable complaint both in European and American spinning mills. The objectionable stains and dye

trouble in finished goods were serious enough to cause a general ban on the coating in 1948. It is reported that a new type of plastic coated tie has been developed and that it has been decided to try it out during the 1950 season.

Conclusions and General Recommendations

Many of the facts presented are not new. It may be surprising to state that a good deal of the information has been reported at different times and as long as twenty years ago. The apparent inaction in applying corrective measures, developed by authoritative fire prevention and protection groups, results from simple indifference and gross carelessness. There appears to be a distinct lack of appreciation that cotton has a high flash-fire hazard.

It is to be appreciated that cotton is handled and rehandled to a considerable extent from the farm to the gin and on to the warehouses, compresses, and in transportation systems as it is prepared and forwarded to the textile spinning mills. In this manner it is besieged by the factor of human temperament at every turn. To say the least, it is handled in a rather slovenly manner in most locations. The ragged traditional sample openings, for example, present an exposed "wicking" of loose material which will readily permit passage and rapid spread of fire from one adjoining bale to another. This must be seriously regarded as a potential fire hazard. In the opinion of one official, it appears that in locations harboring such serious fire safety violations, "Providence has kept many fires away at arm's length by a hair's breadth."

The cotton fire problem is a big one and its solution involves each of the many directly concerned groups: the cotton producers and processers; the warehousemen and shippers; equipment manufacturers and their representative trade groups; fire safety and insurance interests.

Cutting of bales for sampling. Note wicking effect of exposed cotton permitting rapid spread of fire.

The following phases of fire safety action and research effort are indicated:

Increased Education

The dangerous combustible nature of cotton must be stressed and lesser-known and little-appreciated hazards should be presented in a manner to capture proper attention. Provide instruction which will promote easy recognition of hazardous conditions and practices. Establish proper discipline with regard to smoking and use of matches. Personnel should be trained in the knack of fire fighting and drilled to act promptly under any emergencies, whether in the yard areas, gin plants, or in warehousing and transportation situations. Proper first-aid safeguards for fire control must be provided in accordance with recognized standards in order to secure effective action.

Housekeeping

Regular cleanup schedules, periodic inspection of equipment for mechanical defects and worn parts, and follow-up maintenance are reflective of good management and trained workers.

Research and Technical Developments

The following projects are indicated as worthwhile and progressive avenues of attack:

Mechanical or Frictional Sparks

Investigation should be made of the possible use of new permanent type, high-flux magnets for removal of all extraneous metal objects, tramp iron, and broken machinery parts from gin feed-stock. It may prove profitable to examine the applicability of nonsparking copper-beryllium alloys in high-speed rotors or adjacent stationary parts which may provide contact and spark on distortion or misalignment. Infra-red drying lamps warrant consideration in operations encountering damp or incompletely dried seed-cotton.

Static Control

Make a study of the efficiency of static elimination by "atmospheric grounding" with radiation from ultra-violet units and radioactive isotope tapes. New developments in fluorescent lamps and increased availability of isotope materials should make this a promising application. Controlled humidification and moisture restoration with sprays containing chemical conditioners or "wet water" agents hold promise for promoting the cleaning of cotton and elimination of matting and rib-clogging.

Fire-packed Bales

A sensitive infra-red detector (Geiger type) or bayonet thermocouple probe would find wide application for detection of such hidden and smoldering fires. A hollow tubular, thermocouple tipped, bayonet-like instrument to be pierced into a bale at various points on the alternate sides of a suspected fire-packed bale might be developed. A temperature recording instrument attached to the handle, or the smell or visual appearance of smoke (if the tube be properly perforated) could be employed for detection of fire. This same equipment could be used as a dual purpose tool for extinguishment, once the location of fire is determined, by connecting either an inert gas or a vaporizing liquid extinguisher or a source of wet water media to the outer open end of the tube. One or two such devices are now in the state of development in the field.

Improvement of Process Equipment

There appears to be a need for continued improvements in preliminary drying, extraction and cleaning processes, and in feeding devices of gin equipment. Planned changes should also include adaptation of interlocked temperature control and fire detection and extinguishment facilities to afford prompt detection and quick extinguishment of fires in their incipiency. This recommendation applies in particular to the larger installations.

Incinerators

Considerable inventiveness has been evidenced in the design of a wide variety of incinerators, by trial and error. Combustion and incineration practices established in other fields of engineering endeavor would go a long way in providing an early solution for a successful and standardized design.

Tie-bands and Buckles

There is a serious need to study tie-band failures, and the damaging role played by the sharp-edged band buckle. The possibility of ignition by heat generated through metal-to-metal friction encoun-

tered in long distance transportation should also be considered. Peculiar "necking down" fatigue behavior of such bands under fire conditions warrants investigation of physical characteristics (tensile strength, yield or elongation) on acceptable and sub-standard steel material that might be employed for this purpose. The practice of using riveted short pieces of salvaged bands should be looked into in the course of the foregoing studies. The use of suitable coatings (plastics, lacquers, etc.) to eliminate staining of cotton stock and to control the spark-ignition hazard warrants special consideration. An industry-wide standard should be considered in connection with the investigations suggested.

Loading for Safer Transportation

Improvement is needed in the current methods of loading cotton bales in freight cars to withstand the increased rail speeds and to minimize shifting loads and the breaking of tie-bands. Besides the establishment of proper loading patterns, there is need to set up regulations to insure clean and properly prepared cars, with nails and metal fastenings removed. Safeguards should also be considered for transportation on highways by trucks.

Mobile pressurized "wet water" tank mounted on trailer. Suitable for towing by jeeps or tractors.

Tractors

There is need for fire safety in the servicing of tractors employed in warehouses. Regular mechanical servicing, to insure proper maintenance of such equipment and their protective devices, should be a regular policy.

Fire Protection Equipment for Yards

The pressurized "wet water" mobile trailer (200 gal. capacity at 125 psi, equipped with 25 ft. of 1-inch line and adjustable nozzle), capable of providing a continuous 10-minute stream supply, appears to need further thought on protecting the gauge, safety and fill-in valves, in the event of tipping. The front-wheel assembly should be arranged to withstand travel over rough terrain and avoid bending of axle and jamming of the wheel. Effectiveness of the dry powder (sodium bicarbonate) dusting technique to reduce ignition and spread of fire should be observed and experiences reported on in detail.

Acknowledgments

Acknowledgment must be made of the valuable cooperation extended in this survey by the Cotton Warehouse Inspection Service, Memphis; Cotton Fire and Marine Underwriters, Memphis; Cotton Insurance Association, Atlanta; Fire Prevention and Engineering Bureau of Texas, Dallas; South-Eastern Underwriters Association, Atlanta, and the Railroad Insurance Association, New York. Appreciation is also expressed to the following agencies for their helpful assistance: the U. S. Department of Agriculture's Cotton Ginning Laboratory at Stoneville, Miss. and the Cotton Field Station at Shafter, California; the United States Bureau of Mines' office at Dallas; the Fire Protection and Insurance Section of the Association of American Railroads, Chicago; the Texas Cotton Ginners' Association, Dallas; the National Cotton Council of America, Memphis; and the National Cotton Compress and Cotton Warehouse Association, Memphis.

A-Bomb and H-Bomb Defenses

By Horatio Bond

Chief Engineer, National Fire Protection Association

From various sources official and unofficial, come more bits and pieces of technical information on A-Bomb and H-Bomb problems. Some of these throw light on the kinds of problems with which we are faced in connection with building construction, city planning, water supply and fire-fighting operations in an A-bomb attack. The H-Bomb data are mostly conjectures.

Atomic Burns and Contamination

The National Security Resources Board, charged with responsibility for civil defense planning, continues its policy of providing as much helpful information to the governors of states and other officials as is made available to the Board from the other agencies of the federal government. A recent statement "Medical Aspects of Atomic Weapons," prepared by the Department of Defense and the U. S. Atomic Energy Commission, is given in a 24-page pamphlet which can be obtained from the U. S. Superintendent of Documents, Washington, D. C., for 10¢.

This document primarily interprets data from the Japanese bombings in which an atomic bomb, considered as roughly equivalent to setting off 20,000 tons of TNT, was exploded at a height of about 2,000 feet above the earth on a clear day. The Hiroshima and Nagasaki bombs caused total destruction and serious damage to buildings, including death and injury to people for 2 miles from the point at which the bomb was set off. The extreme limit of damage was about 4 miles.

In the case of such a high air blast as in Japan, some 15 to 20 per cent of the deaths will probably be caused solely by nuclear radiation, according to this official statement. It says also that the remaining 80 to 85 per cent will be caused primarily by injuries suffered in the collapse of buildings and by burns, although many of these also may be expected to suffer severe radiation exposure. It should be kept in mind that these figures are based on what happens in a Japanese city. The writers of this official document, as usual, miss the point that all cities are not like Japanese cities and that the extent to which a city may be expected to burn determines the resulting fire injuries. The report goes on to predict that it would be unrealistic to prepare for fewer than 40,000 to 50,000 severely burned persons from a single atomic explosion. This estimate is based on the assumption, which is by no means true, that all cities are going to have the same kind of fires as the wooden cities of Hiroshima and Nagasaki. The radiation hazard, the statement points out, is that within a half-mile radius of the ground center of the atomic exposure, nearly everyone not protected by earth, steel or thick concrete would die because of the concentration of radiation. At about 1½ to 2 miles, some flash burns could be expected but probably little radiation sickness.

The document contains the following statement:

"Much concern has been expressed regarding the contamination of drinking water. In a high air burst on a clear day, the fall out of radioactive materials is so small that dilution by the water probably ensures safety. The efficiency of the filtration plants, and the distance of sources of supply from cities are further safety factors. Fission products and fissionable material have a tendency to adhere to any organic material with which they come in contact. They will cling to the banks and the bottom of lakes, to the pipes, and other material to such a degree that it is probable that very little would ever reach the populace. Water containing one-millionth of a curie of fission products per liter is considered safe for drinking. Many popular mineral waters contain more than this. Hazards in the case of a storm or base surge remain to be evaluated. Testing for radioactivity is advisable. At Bikini, sea water from a heavily contaminated source was distilled and found safe for drinking purposes."

As to the hazard of inhaling particles of matter, the size of the particle is said to be important. A combat-type gas mask will filter out 99.999 per cent of all dangerous particles.

Wounds should be cared for in the same manner as any similar injury in an uncontaminated area.

The chief external radiation hazard in a contaminated area will come from gamma-rays thrown off by fission products or by materials made radioactive by neutrons or gamma rays during the explosion . Alpha and beta radiations are explained to be dangerous chiefly if they come into actual contact with the skin, but it will be necessary to guard against contaminated dust. Filter-masks, clothing tight at wrists, ankles, and neck, and tight-wristed gloves will afford protection against alpha and beta particles. Clothing should be discarded at the edge of the contaminated area to avoid spreading radioactive contamination. Thorough soap-and-water bathing would be a valuable precaution. Gamma radiation cannot be turned aside by such simple measures as protective clothing, but dense material, such as concrete, can reduce its ionizing effect. Gamma radiation from contamination will not approach the power of direct bomb radiation, but it can still be severe. The best protection against contamination that gives off gamma radiation is to use instruments to detect its presence and to avoid any dangerous concentration.

What is a dangerous concentration of ionizing radiation? In the atomic energy program, a standard has been set, called the maximum permissible dose, which stipulates an exposure which experts believe a man could experience every day in his life without danger of injury. This has been fixed at a maximum of one-tenth of a roentgen a day with a weekly maximum of three-tenths of a roentgen. In emergency operations, a body could probably be exposed to 50 roentgens of total body radiation without injury and be able to continue at his duties, it is reported. The rate of exposure is of considerable importance. A person who receives 600 roentgens in a single exposure within a few minutes will have small chance of survival, but if a man received only 30 roentgens a day it would probably take a total of as much as 1,800 roentgens to prove fatal.

Protection from Atomic Explosion

The second report in a series prepared for the National Security Resources Board by the Department of Defense and the U. S. Atomic Energy Commission was sent to governors of states in February. It is entitled "Damage from Atomic Explosion and Design of Protective Structures." It is being printed and will be shortly available from the U. S. Government Printing Office at 10¢. The principal value of the report is an official interpretation of the lessons of atomic bomb explosions as on

Hiroshima and Nagasaki. It describes the huge shock which the bomb blast puts on structures. Damage is due to a push from the blast followed by a suction push back toward the source of the blast. Buildings are not ordinarily designed to resist such loads. Some additional wind load in design appears to be one of the methods by which damage from future atomic explosions can be lessened. The report will be of interest to structural engineers for its detailed discussion of this and other features of building design.

The report contains valuable general suggestions for reducing the vulnerability of individual buildings. It indicates measures of protection that can be provided by site planning, design of new structures, and modification of existing structures. It points out that location is of primary importance and suggests both dispersion and duplication of essential buildings and facilities, with some very important facilities being placed underground.

It suggests that civil defense control centers should be provided at two or more locations, at least three miles from a probable target area. It suggests duplication of electric power sources and water supplies. It urges that buildings, so far as possible, be designed so that flying glass, plaster and furniture shall cause a minimum amount of injury to people.

While specific discussion of fire protection contains a number of technical errors, the general advice given is along proper lines. It points out that narrow fire breaks in the Japanese cities were of little use in areas of wood frame construction.

It makes the error, which appears to be in the minds of many people who have studied Japanese cities and their reaction to the atomic bombs, that all other cities are going to react the same way. It says that provision of an adequate water supply is probably the most important single element in the control of fires. In Japanese cities, some of the fires were successfully fought and water supply proved important. It points out that storage tanks for local water supply would be of value but only for incipient local fires. The report concludes that such tanks would probably have limited value in large-scale fire fighting operations. As a matter of fact unless storage tanks are provided for local supply. it will probably not be possible to engage in large-scale fire fighting operations at all.

The report stressses the desirability of locating fire stations on the outskirts of the city. It implies that effective fire department mutual aid is dependent principally on standardization of hose couplings or the use of adapters. This, of course, is not a major problem in joint fire defense planning among cities and appears trivial in comparison with the organizational problem involved.

The report includes suggestions for the construction of shelters. It is possible, of course, to design shelters giving almost complete protection but only at prohibitive expense and inconveniences to people. On the other hand, shelters could be provided which will give a considerable measure of protection against all except direct hits. For the bulk of the population, shelters giving some protection are suggested. This, in general, was the shelter policy followed in England in World War II.

Radiological Monitoring

The National Security Resources Board in February invited governors of the States and Territories to nominate candidates for two series of teacher-training courses in techniques for dealing with effects of

atomic attack. One of these series of courses will be devoted to the medical aspects and for these the governors were asked to nominate physicians or teachers in medical schools. For the course in radiological monitoring, the governors were asked to choose individuals who have experience in modern or nuclear physics or electrical or chemical engineering, plus considerable teaching ability. The 5-week courses are designed to lay the ground work of development and operation of similar training programs by the states.

The H-Bomb

It was emphasized in the NFPA book "Fire and the Air War" (1946) that the spreading out of cities and the taking of space was the only practical defense against incendiaries and A-bombs. It was pointed out in that text, and in a number of papers I have subsequently prepared, that it is necessary for the National Military Establishment to define the vulnerability of cities in order that appropriate action can be taken by state and city planning authorities to make the urban centers of the country progressively less attractive as targets. Strong support for this point of view has been forthcoming from one authority on the A-bomb, Dr. R. E. Lapp. During the war, he was assistant director of the Manhattan Project, which built the A-bomb, and was later executive director of the Committee on Atomic Energy of the Research and Development Board of the National Military Establishment. Most helpful for understanding the problems of A-bomb attacks on cities was Dr. Lapp's book, "Must We Hide?" (Addison—Wesley Press, Inc., Cambridge, Mass., 1949).

In a recent public address, Dr. Lapp describes certain considerations which may affect the use of H-bombs, when, as, and if they become a reality.

It appears that no one yet has an H-bomb and how much time it will take to develop one, if one in fact can be developed, is still uncertain. We have some time to consider our defenses, but it may not be very much time.

The H-bomb mechanism depends upon the principle of fusion of hydrogen, a process the opposite of uranium fission, says Dr. Lapp, which is simply the welding together of two light nuclei to form a single heavy nucleus as, for example, hydrogen combining to give helium as it does in the sun. The trick is that for the reaction to work the atoms have to be agitated to the very high velocity such as one finds inside the hot stars or in our sun. The advent of the A-bomb has allowed men to realize sun-like temperatures here on earth.

From a theoretical viewpoint, the H-bomb could be made in any desired size. Dr. Lapp says he would think of the H-bomb, if perfected, as being from 10 to 50 times more powerful than the 1945 Nagasaki type bomb.

The size of the bomb is dictated not by theory but by the size of the target. We have 20 million people in our five largest cities: New York, Chicago, Philadelphia, Detroit and Los Angeles. These vary in area from 130 to over 300 square miles of central metropolitan area. Our next 22 cities in order of population have central areas ranging from about 40 to 80 square miles. A total population in these cities is close to 20 million. The H-bomb target for an enemy would be these 27 largest cities, in which more than one fourth of our total population is concentrated. Against these targets, Dr. Lapp believes the enemy would want to use an H-bomb of between 200 and 500 kilotons. With

35 such bombs, an enemy could decimate the U. S. metropolitan population in surprise attacks. I think there is general agreement that it is not going to be possible to completely avoid such attacks.

Dr. Lapp agrees that civil defense measures will be of such great importance that the eventual result will be a federal civil defense department with a cabinet officer in charge: a Civil Defense Establishment coordinate with the Department of Defense. The handling of civil defense matters by the National Security Resources Board has brought about virtually that situation now.

Two important phases of this civil defense establishment would deal with the defense of cities and the arrangement of industrial communities in order to reduce the attractiveness of both cities and industrial establishments as bomb targets. The city defense service would, as a national defense measure, indicate to the states that critical cities must be definitely limited in size. The construction of sky scrapers and other population-congesting buildings would be vetoed as a national defense measure. As far as possible, obsolete buildings would be removed and rebuilding permitted only to the extent consistent with not increasing the number of people subject to destruction in a single bomb attack. These common sense measures are exactly in line with measures for ordinary fire safety and ways of working them out will undoubtedly be the subject of lively discussions in the near future.

Fire Precautions with Uranium

By Edward J. Kehoe, Francis L. Brannigan, Merril Eisenbud,
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Uranium metal is pyrophoric, which means that in finely divided form it may ignite spontaneously on contact with air. While this reaction may occur regardless of whether the uranium powder is dry or moist, it occurs more readily in the moist state at slightly elevated temperatures. The dried uranium powder can also be ignited by rough handling. Uranium turnings and chips are easily ignited by an outside source of ignition.

The term "uranium scrap" is used in this article to include uranium turnings, chips, borings, sawdust and powder. Such miscellaneous scrap may include material of all sizes from dust to turnings, in addition to oil, water, and foreign matter such as floor scrapings, organic waste, etc.

Storage

The amount of uranium scrap in storage should be kept at a minimum. Protection is increased through isolation and separation of the material on hand into small batches. Fire resistive storage facilities are recommended.

The temperature of a mass of burning uranium approaches 2300°F; accordingly it is necessary to isolate uranium storage from other combustible materials.[1]

Scrap may be stored under a mineral oil or under water. However, in the case of the water, provision must be made for the

safe ventilation of the resultant hydrogen gas, since the scrap slowly oxidizes in contact with water, releasing free hydrogen. Consequently, storage under a mineral oil is generally preferable to storage under water.[1]

The storage of scrap only partially submerged in oil or water is dangerous. Ignition is very apt to occur at the liquid line. The reaction is particularly severe in the case of water, since the water boils off through the mass of burning metal with the liberation of large quantities of hydrogen. In one such fire, involving an insufficiency of water, holes were burned through a metal drum by the fire, and hydrogen flames several feet long shot out in addition to flames ten feet high from the top of the drum. If the liquid is oil, it too will probably ignite and add to the fire. By all means avoid leaving exposed to air scrap just moist with oil or water.[1]

When not stored properly, as for example when only partially covered with oil or water, incipient spontaneous ignition can usually be detected by the heating of the container; there is usually a marked increase in temperature which can be detected by the hand for some time prior to ignition.[1]

Automatic sprinkler systems provide satisfactory protection for uranium turnings, chips and borings and for the small quantities of sawdust or powder generally encountered in a machine shop or laboratory; while hydrogen is evolved from the water, it burns off readily under control and the sprinklers prevent the extension of the fire. In the unusual cases where extremely large quantities of uranium dust or powder may be involved, an inerting system utilizing a gas which is non-reactive with uranium, such as argon, may be in order.

Laboratory Handling

In handling uranium scrap, every possible source of heat or spark should be eliminated. It is advisable to handle the material wet or under an argon atmosphere. Specially constructed explosion-safe argon dry boxes have been found very satisfactory where extremely pyrophoric forms are involved. Actually, extremely pyrophoric forms of uranium powder may burn so rapidly as to have the effect of an explosion.

If for some reason ordinary laboratory glassware is used in lieu of such a dry box, safety glass screens and face shields are minimum protection. The work area should be kept clean of flammable liquids and other materials which might cause fires which would spread to the uranium. Quantities exposed at any one time should be kept to a minimum.

Safe Disposal of Uranium Scrap

Uranium scrap may be disposed of by controlled oxidation, by safe shipping to a recovery facility or by conversion to a compact form to reduce the exposure to air. Specifically, these methods include the following, each of which will be briefly described:

1. Wet burning.
2. Dry burning.
3. Shipment under oil.
4. Nitric acid oxidation.
5. Degreasing, briquetting and vacuum casting.
6. Shipment under argon.

WET BURNING. This method requires special equipment in which uranium scrap is oxidized under water by means of steam jets. Hydrogen is liberated. The process is carried out at the boiling point of water. An advantage of this method is that atmospheric contamination is reduced to a mini-

mum. This method is desirable only at locations where fairly large quantities of material must be disposed of on a recurring basis.[2]

DRY BURNING. The most expeditious and least expensive method for the disposal of uranium scraps by conversion to oxide is by direct dry burning in air.

For a quantity not exceeding 5 lbs., the scrap may be spread out on a steel plate in an open area and burned to oxide by the flame of an oxy-acetelene torch. The worker should be protected by a welder's face shield and a metal fume respirator. The scrap should be raked to insure that all the metal goes to oxide.

Where larger quantities are involved, a steel cased incinerator with heavy steel flooring is necessary, equipped with a continuous source of combustion to maintain a satisfactory rate of combustion, a rake to permit turning over the material at frequent intervals, an exhaust system to a suitable flue, and dust collection equipment which will withstand hot gases and possible incandescent particles. A muffle furnace has been used successfully with very low loss.

SHIPMENT UNDER OIL. In the event that it is impossible for some reason to dispose of uranium scrap by oxidation, the scrap may be shipped under a mineral oil; however, this method should be avoided if at all possible. *Shipment under oil should not be undertaken without prior approval of the Production Division, New York Operations Office, Atomic Energy Commission.*

NITRIC ACID OXIDATION. Small quantities of uranium scrap can be oxidized to uranyl nitrate with nitric acid. The reaction should be performed in a wall ventilated hood, in a container sufficiently large to prevent boil over. The vent is important because of the highly toxic nitric oxide fumes and hydrogen evolutions.

DEGREASING, BRIQUETTING AND VACUUM CASTING. This method requires extensive equipment and involves the complete degreasing of the material, removal of impurities and briquetting at pressures of 15,000 to 20,000 psi. It is practical only for the disposition of large quantities of material on a production basis. Actually, it is concerned with converting the scrap to a readily usable form rather than with simply converting it to oxide for disposal.[1]

SHIPMENT UNDER ARGON. In unusual cases, it is necessary to ship fine uranium powder as such without conversion to oxide and it is possible to ship small quantities of the powder under an atmosphere of argon and at dry ice temperature. *Shipment under argon should not be undertaken without prior approval of the Production Division, New York Operations Office.* Such shipments, if made, will be by courier rather than common carrier.

I. C. C. Regulations

The Interstate Commerce Commission regulations concerning radiation are found in Supplement 18 to Freight Tariff No. 4, Sections 366-369 (shippers are referred to the appropriate freight tariff, Civil Aeronautics Authority or Postal Regulations for exact packaging and labeling information on radioactive materials). The limitation on the amount of uranium permitted to be shipped by express in one package is set at that amount disintegrating at the rate of 10^{11} atoms per second, which would be approximately 17,000 lbs. This limitation is obviously of little significance with respect to the weight of uranium metal in

express shipments. The minimum amount requiring labeling is set at that amount disintegrating at the rate of 50×10^6 atoms per second, which would be approximately 8.5 lbs.

While the regulations of the Interstate Commerce Commission are not presently directed towards the pyrophoric properties of uranium scrap, the general regulations require the shipper of dangerous articles to describe, pack and mark his packages properly and to inform the agent of the carrier of the true character of their contents. *Shipments of scrap under oil will be made by courier, rather than by mail or common carrier.*

Fire Control

The best fire protection for uranium scrap is provided by keeping quantities small and separated, by segregating the scrap from other flammable materials and by handling and storing uranium in locations suitable for permitting a fire to burn out.

Fires in machining operations can be avoided by prompt removal of scrap out of the region where glowing turnings fall. Formation of a heavy oxide layer will extinguish the combustion of an isolated metal turning. If a small fire occurs it can be extinguished by a gallon or so of the coolant; for this purpose an open top can of the coolant should be kept at hand.

G-1 powder (a commercial preparation with a graphite base), graphite chips, powdered talc or *dry* sand are useful in uranium scrap fires for controlling radiant heat, spatters and fumes. A supply of at least one of these agents should be available at all locations where uranium scrap is handled.

Ordinary fire extinguishers are not suitable. Uranium powder can burn in an atmosphere of carbon dioxide (which eliminates carbon dioxide extinguishers) and reacts to nitride in an atmosphere of nitrogen. The reaction with carbon dioxide also precludes dry chemical since such extinguishers depend on the heat of the fire liberating CO_2 from the breakdown of the bicarbonate of soda. Carbon tetrachloride extinguishers should not be used because of the undesirability of releasing carbon tetrachloride fumes in a confined space and because the hot metal present may possibly cause decomposition of the carbon tetrachloride. Soda-acid and foam extingushers are not recommended, since they may cause scattering of the burning material and at best require extremely skillful handling to have any beneficial effect on burning uranium. Hose streams should be avoided. However, as mentioned above under Storage, automatic sprinklers are satisfactory unless an extremely large quantity of powdered uranium is involved; this would by no means constitute the usual situation.

Inhalation of the fumes from burning uranium metal should be avoided. If the burning occurs under controlled conditions, such as the burning of a small quantity in a laboratory, the hoods ordinarily used in handling the uranium will provide sufficient ventilation. However, if the burning does not take place under controlled conditions, approved breathing apparatus should be worn.

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[1]Based upon Report A-4044, December 1945.

[2]Letter from Mallinckrodt Chemical Works to Manager, St. Louis Area Office, U. S. Atomic Energy Commission, November 23, 1949.

Flammable Limits at Oven Temperatures*

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The potential fire and explosion hazards incidental to the operation of industrial ovens have long been of concern to all interested parties, particularly where the raw materials or articles heated in the ovens evolve combustible vapors. Ventilation, mechanical or forced, is usually employed to dilute the concentration of these combustible vapors below their lower flammable limits in air, and to remove them from the oven. Information as to the lower flammable limits of the combustible vapors in question is therefore needed in order to determine the amount of ventilation required for safe operation of an oven. While there are considerable data in the technical literature on the lower flammable limits of vapors at ordinary (room) temperatures, data on lower flammable limits at elevated temperatures of the order of those likely to be encountered in ovens are meager or lacking in the case of many common solvents.

As an additional safeguard, temperature control of ovens is required to prevent overheating of materials or articles being processed, and in many cases is depended upon to prevent heating of flammable vapors to the ignition temperature. Much information is available as to ignition temperature of various flammable vapors, but there are few data bearing on the influence, if any, which the catalytic or other actions of common metals or their oxides encountered in oven construction may exert on the ignition temperature of vapors.

The goal of this investigation was to obtain definite information on the lower explosive limits and the ignition temperature of certain common solvent vapors encountered in industrial drying ovens under operating conditions for the purpose of guiding the ventilation and design requirements.

The nature of the combustible vapors encountered in industrial ovens will depend primarily on the solvents or reactants used in the process and not removed from the products prior to the drying or baking operations conducted in the ovens. Nineteen common flammable solvents were included in the investigation.

Theoretical Considerations

Flammable Limits. No method has yet been devised for calculating lower (or upper) flammable limits of gas or vapor-air mixtures from more fundamental data, and they must, therefore, be determined experimentally. The limits depend upon the initial temperature and pressure, the shape and dimensions of the confining vessel, the direction of flame propagation, turbulence, and, to some extent, the source of ignition.

Ordinary variations in atmospheric temperature have little effect on limits of flammability, but at the higher temperatures often attained in ovens, a substantial decrease in the lower limit is to be antici-

*Condensation of Bulletin of Research No. 43, "The Lower Limit of Flammability and the Autogenous Ignition Temperature of Certain Common Solvent Vapors Encountered in Ovens," published in January 1950 by Underwriters' Laboratories, Inc. For further details on the various phases of the investigation and extensive tabulation of results, refer to the above Bulletin.

pated, which may be of considerable significance with respect to the ventilation required for safe operation of the oven.

Reduction of initial pressure below atmospheric causes an increase in the lower flammable limit and a narrowing of the flammable range, but the effect of pressure greater than atmospheric appears to differ with individual gases and vapors. Normal variations in atmospheric pressure, however, have practically no influence on the flammable limits. Since industrial ovens are operated for the most part at pressure very close to atmospheric, the flammable limit determinations in this investigation were conducted at atmospheric pressure.

Ordinary changes in atmospheric humidity affect the lower flammable limit of combustible vapors only slightly (by displacement of oxygen). The samples of solvents used in determination of lower flammable limits in the investigation were treated to remove water, but the air supply was at the relative humidity prevailing in the laboratory.

Although determinations have shown that the lower limit falls and the upper rises as the diameter of the tube (explosion vessel) is increased, there is little if any change in the limits when the diameter is increased above 2 inches. Also, the explosion vessel must be of sufficient length to permit differentiation between localized combustion and actual flame propagation. The explosion vessel used in this investigation was a cylindrical chamber of steel 12 in. internal diameter and 15¼ in. in height.

Upward flame propagation, in general, gives lower flammable limits than does horizontal or downward propagation. Determinations in this investigation were conducted with the source of ignition near the bottom of the explosion vessel.

In this investigation, the flammable limit determinations were conducted for the most part with the vapor-air mixture quiescent. It has been shown that the lower limits are slightly reduced in certain cases by turbulence, and some tests bearing on this feature were conducted on mixtures of representative vapors and air.

Ignition Temperature. When the temperature of a flammable vapor in air is raised sufficiently, reaction with oxygen is initiated, and if the temperature is high enough, ignition occurs. The ignition temperature of flammable vapors is considerably below the temperature of flames and sparks, and the ignition temperature of a large number of vapors is below red heat. A moderately hot surface may ignite some vapors.

When a flammable vapor-air mixture is heated to ignition by contact with the interior surface of an externally heated vessel, there is an initial period of chemical reaction known as the "lag," in which there is no visible flame, although the vapor may undergo oxidation or partial combustion. It may range from a fraction of a second to minutes, depending mainly upon the temperature of the heated surface, the nature of the vapor, its concentration in air, and the experimental conditions.

A number of other factors, such as catalytic and other actions of the heated surface, and surface combustion influence the ignition temperature. Therefore, in addition to combustion chambers of glass and quartz, which have comparatively low catalytic effects, chambers were used in these tests having inner surfaces of common metals used in oven construction as follows: iron, stainless steel (AISI Type No. 302), copper, zinc and yellow brass.

Table I

Lower Limits of Flammability of Solvent Vapors in Air at Elevated Temperatures

Solvent	Flash Pt. Closed Cup	Per Cent Vapor by Volume at Initial Temperature, F						
		Room	212	392	437	482	572	662
Acetone	(3)†	2.67	2.40	2.00 (†††)		...	...	...
Amyl Acetate, Iso	(77)†	...	1.00	0.82	...	0.76 (†††)		...
Benzene	(−4)†	1.32	1.10	0.93	...	...	0.80 (†††)	
Butyl Alcohol, Normal	(100)†	...	1.56	1.27	1.22 (†††)		...	...
Cresol, Meta-Para	(202)	...	1.06(††)	0.93	...	0.88 (†††)		...
Cyclohexane	(−4)	1.12	1.01	0.83 (†††)		...	...	...
Cyclohexanone	(111)	...	1.11	0.96	0.94	0.91 (†††)		...
Ethyl Alcohol	(54)†	3.48	3.01	2.64	...	2.47	2.29 (†††)	
Ethyl Lactate	(131)	...	1.55	1.29	...	1.22 (†††)		...
Gasoline	(−45)†	1.07	0.94	0.77 (†††)		...	...	...
Hexane, Normal	(−15)†	1.08	0.90	0.72 (†††)		...	...	...
High Solvency Petroleum Naphtha	(36)	1.00	0.89	0.74	0.72	0.69 (†††)		...
Methyl Alcohol	(52)†	6.70	5.80	4.81	...	4.62	4.44 (†††)	
Methyl Ethyl Ketone	(21)	1.83	1.70	1.33 (†††)		...	...	...
Methyl Lactate	(121)	...	2.21	1.86	1.80	1.75 (†††)		...
Mineral Spirits, No. 10	(104)	...	0.77	0.63 (†††)		...	...	...
Toluene	(48)†	1.17	0.99	0.82	...	...	0.72 (†††)	
Turpentine	(95)	...	0.69	0.54 (†††)		...	...	...
VM&P Naphtha	(28)	0.92	0.76	0.67 (†††)		...	...	...

†Data reported in Underwriters' Laboratories, Inc., Bulletin of Research No. 29.

††Lower limit determined at 302°F.

†††Rapid and extensive thermal decomposition and oxidation reactions in vapor-air mixture at this temperature.

Apparatus and Test Procedure

Flammable limit apparatus consisted essentially of a closed cylindrical explosion vessel of steel, 12 in. in diameter and 15¼ in. high, inside dimensions.

Apparatus used in determining ignition temperatures was essentially a combustion chamber approximately 160-ml capacity surrounded by a molten alloy bath. The combustion chamber consisted of a conical flask 4½ in. high, 2½ in. diameter at the bottom and 1 in. diameter at the top.

Flash points of those solvents not previously determined and reported in Underwriters' Laboratories, Inc., Bulletin of Research No. 29, were determined. Details of apparatus and test procedure for flash point determinations are included in the original report.

Results of Determination

Lower Limit of Flammability: The lower limits of flammability of all solvents included in this investigation were lowered on increasing the initial temperature, these changes being of such magnitude that they cannot be safely neglected in practical calculation of the amount of ventilation required to prevent formation of hazardous concentrations of the vapors of solvents in industrial ovens. Results are tabulated in Table I. For purposes of comparison the maximum number of cubic feet of air, measured initially at 70°F and 29.92 in Hg, which are rendered flammable by 1 lb. of the various solvents are shown on Table II. The maximum number of cubic feet or air, measured at various elevated temperatures and 29.92 in Hg rendered flammable by 1 lb. of the various

Table II

Maximum Cubic Feet of Air Measured at 70°F and 29.92 In. Hg Rendered Flammable by One Pound of Solvent When Air and Solvent Are Heated to Elevated Temperatures

Solvent	Temperature F						
	70	212	392	437	482	572	662
Acetone	243	271	327	(†††)	...	...	...
Amyl Acetate, Iso	(†)	294	339	...	388	(†††)	...
Benzene	370	446	527	...	...	615	(†††)
Butyl Alcohol, Normal	(†)	329	406	422	(†††)	...	...
Cresol, Meta-Para	(†)	334(††)	381	...	403	(†††)	...
Cyclohexane	406	451	549	(†††)	...	...	...
Cyclohexanone	(†)	351	407	416	429	(†††)	...
Ethyl Alcohol	233	271	310	...	332	358	(†††)
Ethyl Lactate	(†)	208	250	...	265	(†††)	...
Gasoline	391	444	546	(†††)	...	...	...
Hexane, Normal	411	494	619	(†††)	...	...	...
High Solvency Petroleum Naphtha	375	431	505	523	562	(†††)	...
Methyl Alcohol	168	197	238	...	249	260	(†††)
Methyl Ethyl Ketone	288	311	398	(†††)	...	...	...
Methyl Lactate	(†)	165	196	203	209	(†††)	...
Mineral Spirits, No. 10	(†)	449	550	(†††)	...	...	...
Toluene	354	420	507	...	...	579	(†††)
Turpentine	(†)	398	509	(†††)	...	...	...
VM&P Naphtha	386	468	532	(†††)	...	...	...

†Vapor given off at 70°F by this solvent not sufficient to form flammable mixtures with the surrounding air.

††Temperature 302°F.

†††Rapid and extensive thermal decomposition and oxidation reactions in vapor-air mixture at this temperature.

Table III

Maximum Cubic Feet of Air Measured at Elevated Temperatures and 29.92 In. Hg Rendered Flammable by One Pound of Solvent

Solvent	Temperature F						
	70	212	392	437	482	572	662
Acetone	243	345	525	(†††)	...	...	...
Amyl Acetate, Iso	(†)	373	545	...	691	(†††)	...
Benzene	370	565	847	...	...	1197	(†††)
Butyl Alcohol, Normal	(†)	418	652	715	(†††)	...	...
Cresol, Meta-Para	(†)	480(††)	613	...	718	(†††)	...
Cyclohexane	406	571	883	(†††)	...	...	...
Cyclohexanone	(†)	445	655	704	763	(†††)	...
Ethyl Alcohol	233	344	498	...	589	698	(†††)
Ethyl Lactate	(†)	263	402	...	471	(†††)	...
Gasoline	391	564	877	(†††)	...	...	...
Hexane, Normal	411	627	995	(†††)	...	...	...
High Solvency Petroleum Naphtha	375	546	819	886	998	(†††)	...
Methyl Alcohol	168	249	384	...	444	507	(†††)
Methyl Ethyl Ketone	288	394	640	(†††)	...	...	...
Methyl Lactate	(†)	209	316	344	371	(†††)	...
Mineral Spirits, No. 10	(†)	570	885	(†††)	...	...	...
Toluene	354	532	816	...	...	1127	(†††)
Turpentine	(†)	505	819	(†††)	...	...	...
VM&P Naphtha	386	594	854	(†††)	...	...	...

†Vapor given off at 70°F by this solvent not sufficient to form flammable mixtures with surrounding air.

††Temperature 302°F.

†††Rapid and extensive thermal decomposition and oxidation reactions in vapor-air mixture at this temperature.

Table IV

Ignition Temperature (F) of Solvents in Air

Solvent	Combustion Chamber					
	Glass	Iron	Stainless Steel(††)	Copper	Zinc	Yellow Brass
Acetone	1045(†)	1182	1182	1150	1152	1126
Amyl Acetate, Iso	729	806	675	698	705	680
Benzene	1060(†)	1252	1234	1249	1330	1308
Butyl Alcohol, Normal	689	680	723	595	642	540
Cresol, Meta-Para	1038	968	1053	1276	1185	1189
Cyclohexane	514	543	549	538	540	541
Cyclohexanone	847	986	936	1135	1197	1135
Ethyl Alcohol	793	819	817	772	795	788
Ethyl Lactate	752	833	876	847	792	772
Gasoline	531	540	529	507	547	514
Hexane, Normal	502	511	511	507	509	504
High Solvency Petroleum Naphtha	810	918	849	907	889	941
Methyl Alcohol	867	952	937	959	1015	912
Methyl Ethyl Ketone	941(†)	1161	1105	1094	1225	1141
Methyl Lactate	725	721	709	696	739	687
Mineral Spirits, No. 10	473	473	468	469	475	469
Toluene	1044(†)	1270	1276	1233	1373	1261
Turpentine	491	500	496	495	505	505
VM&P Naphtha	504	511	509	495	513	509

†Determination made in quartz combustion chamber.
††AISI Type No. 302 Stainless steel.

solvents are shown on Table III.

In the practical application of these data in order to prevent explosive concentration, ventilation must exceed the maximum cubic feet of air rendered flammable by the solvent at the existing temperature. In commercial type ovens, vapor-air mixtures may not be consistently uniform and the quantity of solvent may vary considerably. The amount of ventilation required for safe operation may thus be larger than is indicated by calculation based on uniform mixtures.

Ignition Temperatures. In the case of practically all solvents, the ignition temperature obtained in combustion chambers having inner surfaces of the various metals investigated differed from that obtained in glass or quartz combustion chambers. The ignition temperatures of solvents in metal chambers were higher, for the most part, than the ignition temperatures of the same solvent in glass or quartz chambers, but there were exceptions, as shown in Table IV. Effect of metal on ignition temperatures appears to depend on the particular combination of solvent vapor and metal.

Ignition temperatures of many of the solvents are well within the range of temperatures likely to be encountered in industrial ovens. It is apparent, therefore, that if conditions are such as to permit formation of flammable solvent vapor-air mixtures in an oven, ignition may occur.

Hecht Department Store Fire, Baltimore

At 8:53 A.M., March 10, thirty-seven minutes before the Howard Street branch of the Hecht Department Store opened for the day's business, fire flashed from the basement up an open stairway to all five floors. Two of the twelve employees and renovators in the building at the time were killed. The two fatalities would in all probability have been multiplied many times had the fire occurred an hour later with customers and the full complement of 60 employees on hand. The retail stores of North America thus maintain their record of having experienced no major loss of life disasters, although in this fire as in certain others luck rather than a sound safety to life program was responsible. Luck has already run out in other parts of the world, — 41 killed at Ballantyne's Department Store, Christchurch, New Zealand, Nov. 18, 1947; 13 killed at Grafton's, Glasgow, Scotland, May 4, 1949.

Construction

The store occupied a 5-story and basement brick, wood-joisted building, ground floor area 6,534 sq. ft. A brick wall extending from the basement to the fifth floor divided the structure into north and south sections but openings at each floor level were unprotected. A pressed wallboard on wood frame ceiling suspended 18 inches below the bottom of joists formed a blind ceiling space in the basement. The fire originated in this concealed space. Basement walls were lined with combustible insulating board attached to wood strips.

Vertical openings were a vital factor in this fatal fire. There were six. In the north section an open stairway extended from the basement to the first floor. A passenger elevator shaft with metal telescoping doors at each level connected all floors as did a freight elevator shaft. The latter was equipped with tin clad traps on each floor but these had been tied back, making them nonautomatic in operation. In the south section one passenger elevator shaft with metal telescoping doors, one freight elevator shaft with wood doors, and an open stairway extended from the basement to the fifth floor.

The only private protection consisted of 2½-gallon soda and acid extinguishers located throughout the building.

Openings on the first and third floors communicated with an adjoining 3-story building, also occupied by Hecht's. Automatic double fire doors at each opening kept fire from the latter structure.

The Fire

The building was open for employees at 8:00 A.M., March 10 but was not to be opened for customers until 9:30. At 8:45 A.M. there were twelve employees distributed on the various floors as follows: three in the basement, two on the first floor, one on the second, four on the third and two on the fourth.

At 8:50 A.M. two employees entering the south section of the basement noticed fire in the pressed wallboard ceiling. They returned to the north section and up to the first floor to warn other employees. At about the same time, an elevator operator on the first floor saw what appeared to be

Based upon reports submitted by the Baltimore Fire Department and the Maryland Fire Underwriters Rating Bureau.

Wide World

Two employees lost their lives when fire swept from the basement up an open stairway to all floors of the Hecht Department Store in Baltimore, Md. Had it broken out an hour later when customers and the full complement of 60 employees were present the fatalities would probably have been many times greater.

a large ball of fire coming up the open stair that extended from the basement to the fifth floor in the south section. A salesman immediately ran to notify the policeman doing traffic duty outside and then attempted to return but in the brief period of his absence, fire had spread to such proportions on the first floor that he was unable to enter. The other five employees on the basement and first floor had by then made their way to the street. Carpenters at work on the third floor of the south section on seeing flames spreading rapidly up the open stairway made their way to the outside fire escape on the rear of the south section and descended safely.

Two painters on the fourth floor in the north section were not so fortunate. With their backs to the open stairway in the south section, their first indication of fire was intense heat at their backs. Fire had by then burst from the stairway and spread to combustible furniture on the fourth floor. With their path to the outside fire escape in the south section cut off by the fast spreading fire the only alternative escape route was the freight elevator. The car was stopped at the first floor and when attempts to start it failed, the two men jumped into the shaft and slid down the elevator cable to the top of the car. One man left the shaft at the first floor and the other continued in the car to the basement. The latter made his way to the street after removing boards from a basement window but his companion did not escape.

His body was later found in the basement where he had apparently made his way after being unable to leave the building from the first floor.

Firemen found the credit manager slumped at his desk in his second floor office. He had made no effort to escape, apparently having suffered a heart attack. He died of suffocation.

Further indicating the speed with which fire spread through the building is the experience of the first arriving fire companies who found glass in the streets from an explosion on the fifth floor and so much fire in the building that it was impossible to enter. At 10:30 A.M. the building had been sufficiently cooled to allow firemen to enter to look for victims and complete extinguishment with hand lines.

Origin

It has been definitely established that the fire originated in the south section of the basement in the blind ceiling space. From all indications the fire had been burning here for a considerable time before it finally broke through the pressed wallboard ceiling and mushroomed up the open stair to the fifth floor. The cause remains unknown.

Building and contents loss is estimated to be $400,000.

Tire Storage Fire, North Kansas City

On March 15, 1950 fire severely damaged a fire-resistive warehouse of the Goodyear Tire and Rubber Company at North Kansas City, Missouri. Eighty thousand tires and 70,000 tubes in cardboard boxes were in the building. This fire confirms results of small scale test fires conducted on tire storage and offers conclusive proof that specially designed automatic sprinkler protection is the only reliable means of fire control for tire storage areas.* The ease of ignition, the speed and intensity with which rubber fires develop, and the dense black smoke that blankets the fire area even in the early stages make control even by strong manual fire fighting forces highly improbable before extensive damage to both building and contents. This fire also emphasizes the vulnerability of fire-resistive buildings without automatic sprinkler protection to structural damage when exposed to severe contents fires.

Construction

The four-story, 120 ft. x 260 ft. building was constructed of mushroom type reinforced concrete with 8-inch-thick concrete floor slabs. Exterior walls were nonloadbearing brick with steel frame, plain glass windows. Ceiling heights were 15 feet on the first story and 10 feet on the three upper stories. Two stair and two elevator shafts enclosed in 13-inch brick walls connected all floors. Stairshaft doors were double corrugated steel and steel frame. Corrugated steel doors on the 6-foot-wide passenger elevator shaft openings were of the counterbalanced interlocking type. Protection for 12-foot-wide openings on the first, second and third floor in

*For discussion of test fires on tires see "Hazards of High Piled Combustible Stock," by Norman J. Thompson, Director, Factory Mutual Laboratories, presented at 1949 NFPA Annual Meeting and published in the July 1949 QUARTERLY.

Based upon report submitted by the National Inspection Co.

Acme

An intense fire, involving stored rubber tires and tubes, caused collapse of much of the roof and two upper floors of this 4-story reinforced concrete fire-resistive building. Floor slabs were 8 inches thick.

the freight elevator shaft consisted of rigid overhead corrugated steel doors. A rolling steel fire door protected the fourth floor opening.

Contents

The building was used exclusively for storage of motor vehicle tires and tubes. Most of the 80,000 tires in the building were for passenger cars, although some truck and earth mover tires were in the building. The latter were on the first floor. Passenger car tires were stored in piles 50 ft. long, 12 ft. wide and 8 feet high. Piles extended at right angles to and from both sides of a 12-foot-wide central aisle that ran lengthwise through the building on each floor. Five feet clearance was maintained between piles and a minimum of two feet between ends of piles and walls. Piles were not pyramided and for the most part not interlaced. In addition to the tires, 70,000 tubes in cardboard boxes were stored in several places in the building.

Fire Protection

Private protection consisted of four standpipe hoses on each floor and a partial sprinkler system protecting three-quarters of the first floor. The latter was installed by a previous tenant and was still in operation. However, it was not a factor in this fire which did not involve the first floor.

Water at 65 lbs. pressure was supplied to public hydrants on 14-inch mains from two sources, — a pumping station with maximum capacity of 6,000 gpm and a 2,000,000-gallon concrete reservoir. Water supply was barely adequate for a fire of this magnitude even though supplemented by a 500 gpm private fire pump discharging into public mains, and reuse of runoff water pumped from gutters. As the fire

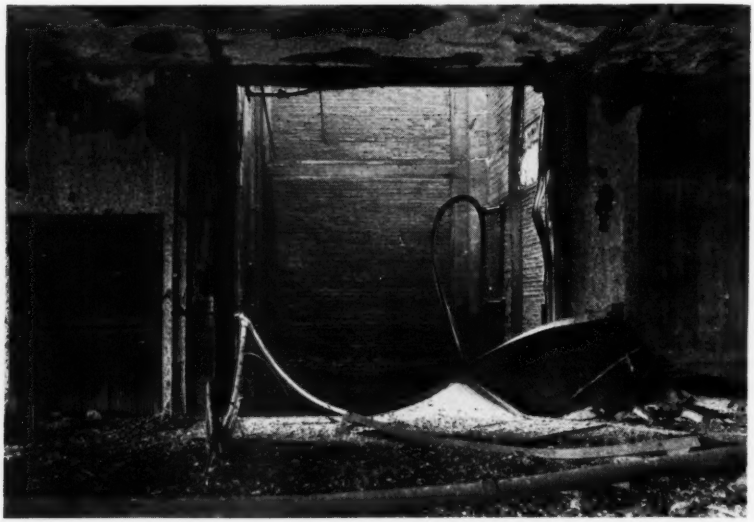
R. M. Hubbell

This picture shows part of the second floor. The "hay" in the foreground is wire beading from burned tires. Striations on the ceiling are exposed reinforcing steel. Collapsed portions of the third floor can be seen at the left rear.

progressed pumper demand exceeded pumping station capacity, resulting in depletion of the reservoir before the fire was out.

The Fire

At approximately 2:30 P.M. smoke was noticed by three employees at work on the third floor. It was traced to a small fire on the end of a pile of tubes about four feet off the floor and directly opposite an open switch and fuse cabinet. From all indications the fire had only been burning a short time and was probably caused by a spark from the fuse box. A standpipe line was run out but when the water was turned on the hose and coupling separated. Another employee then filled a bucket from the standpipe and tossed it on the blaze but with no appreciable effect. Then all pitched in and attempted to pull the burning boxes into the aisle, but about this time the fire mushroomed and forced them from the area. The alarm was then telephoned to the fire department. Although it is impossible to estimate what if any effect this delayed alarm had on the outcome, failure of one of the employees to notify the fire department immediately while the others attempted to control the incipient blaze with first aid equipment cannot be excused. The one engine dispatched on the first alarm arrived in two minutes but smoke was so dense that a call for help was immediately sent. This brought the chief and a ladder company. When the first line laid into the building could not be brought to bear on the fire because of the smoke and heat the other three North Kansas City pumpers were summoned. Volunteer companies from three surrounding communities were also called at this time, although it was not until approximately 5:00 P.M. that Kansas City, Mo. was asked to send as-



R. M. Hubbell

The rigid corrugated steel overhead type freight elevator shaft door at the third story is shown on the floor where it apparently dropped from the open position. The counterbalanced vertically sliding passenger elevator doors are visible at left.

sistance. Absence of a mutual aid agreement was advanced as the reason for this delay. Kansas City, Kansas was asked to send apparatus at 9:30 P.M.

Efforts were made to confine the fire to the third floor but dense smoke and high piling of stock made hose streams ineffective and fire eventually extended to the fourth floor and later to the second through the freight elevator shaft. It appears that the elevator shaft doors were open on the second and third floors and fell to the floor from the open position. The door at the fourth floor apparently did not close entirely. In anticipation of possible spread to the first floor employees knocked open several sprinkler heads above piles of tires. When it was evident that this floor would not become involved sprinkler valves were closed to conserve water.

At one time 20 hose streams were directed at the burning building, but it was not until after considerable areas of the roof, fourth and third floors collapsed and one wall fell in at 11:00 P.M. that water had any noticeable effect. By 5:00 A.M., March 16, the reservoir was depleted but fortunately by this time the fire was sufficiently under control to permit reduction of streams to six. City water pumps were able to supply these and the gradually reduced requirements of the next two days.

Exposures

But for the coincidence of the wind blowing in a non-prevailing direction, a second unsprinklered warehouse containing dried beans valued at $1,000,000 would in all probability have been destroyed. Instead, heat, smoke and flames were blown in the opposite direction to a sprinklered 9-story fire-resistive tenant manufacturing building separated from the fire building by a 90-foot-clear space. Clouds of dense smoke surrounded this

structure and occasionally flames flashed through the smoke. All windows on the exposed side were broken by the heat and wooden window frames on upper floors were ignited. Were it not for the operation of 100 sprinklers (supplied by gravity tanks and later through the pumper connections) the contents of the building would almost certainly have been consumed. As it was, fire entered only at two washrooms where recent construction obstructed sprinkler distribution. These fires were quickly controlled by firemen who had been previously stationed on each floor. Although water damage in this building was heavy it takes little imagination to picture the results had there been no sprinklers.

Loss

Preliminary estimates place damage to the tire warehouse and contents at $1,800,000 and property damage to the exposure $1,250,000. Business interruption loss in the exposed building is estimated at $725,000. Total loss $3,775,000.

Another view of the ruins.

Automatic Sprinkler Tables

The National Fire Protection Association presents a summary of the performance of automatic sprinklers at fires reported to the Department of Fire Record. Similar performance tables have been published periodically, the most recent appearing in the April 1945 *Quarterly*.

These tables show the reliability of automatic sprinklers as a primary means of fire control, and also point out those weaknesses in design or maintenance that can render sprinkler protection ineffective. The record of 96.1 per cent satisfactory performance is a manifestation of the soundness of modern sprinkler standards and a tribute to the careful supervision by inspection departments, property owners, tenants and others responsible for the maintenance of sprinklers in operating condition at all times.

Since numerous fires, extinguished by one or two sprinklers, with a slight loss are not reported to NFPA, the record represents only a fraction of the total number of fires in sprinklered properties. If it were possible to include a complete record, the efficiency of sprinkler performance shown by these tables would even more nearly approach 100 per cent.

The NFPA Fire Record files, maintained since 1897, include reports of 100,178 fires in sprinklered buildings. Of these, there were 17,090, or 17.1%, in which sprinklers were not a factor because the fires were extinguished by other means before automatic sprinklers had an opportunity to operate. Of the remaining 83,088 fires, 32,778 occurred prior to 1925, and 50,310 in 1925-1949, inclusive. The accompanying tables summarize in detail the sprinkler experience of this latter 25-year period.

The present tables in general follow the same pattern as in past analyses, although certain changes have been introduced to increase their usefulness.*

Section I contains a summary of the sprinkler performance in 225 occupancies. It also includes a comparison of sprinkler performance during 1897-1925 with that of 1925-1949, and contains a tabulation of fires occurring during 1925-1949 by the number of sprinklers operating.

Section II lists the reasons for unsatisfactory sprinkler performance by occupancy.

Section III summarizes sprinkler performance in nine broad occupancy groups. Tables show the sprinkler performance record in these groups and summarize the reasons for unsatisfactory sprinkler performance. A detailed analysis of unsatisfactory sprinkler performance is also included.

Certain points of general interest in the tables should be noted. During the period 1925-1949 operation of not more than two sprinklers was required to control 54.5% of the fires and approximately three-quarters of the fires were controlled by less than six sprinklers.

The tables also give an indication of the comparative efficiency of wet and dry systems. In buildings where wet systems were installed, 62.0% of the fires were

*Sprinkler efficiency is reported for 35 new occupancies, and eleven occupancies for which experience was previously reported have been deleted because of the meager information available. A new table reports sprinkler experience by broad occupancy groups.

controlled by two or less sprinklers. The corresponding figure for dry systems was 34.7%.

As revealed in past analyses, closed sprinkler control valves continue to be the most frequent cause of unsatisfactory performance, being responsible for more than one-third of all instances reported.

Sprinkler performance by broad occupancy groups shows that mercantiles with 97.6% efficiency have the best sprinkler performance record, whereas the storage occupancy record of 89.2% efficiency was the least satisfactory.

Grateful acknowledgment is made to the various organizations and individuals who have submitted the large volume of fire reports that form the basis of this analysis.

SECTION I

Table No. 1 — Effect of Sprinklers

	Fires from 1897-1924 Inc. No.	%	Fires from 1925-1949 Inc. No.	%
Practically or entirely extinguished	21843	66.7	33132	65.9
Held fire in check	9545	29.1	15204	30.2
Total Satisfactory	31388	95.8	48336	96.1
Unsatisfactory	1390	4.2	1974	3.9
Total	32778	100.0	50310	100.0

Table No. 2 — Number of Sprinklers Operating — Cumulative

No. of Sprinklers Operating	No. of Fires 1925-1949 Inclusive Wet	%	Dry	%	No Data	Total	%
1	15281	43.5	1887	20.9	1674	18842	37.4
2 or less	21780	62.0	3132	34.7	2519	27431	54.5
3 or less	24917	71.0	3952	43.8	3030	31899	63.4
4 or less	26981	76.7	4588	50.8	3382	34951	69.4
5 or less	28266	80.5	5011	55.6	3585	36862	73.3
6 or less	29305	83.0	5355	59.4	3819	38479	76.5
7 or less	30014	85.4	5667	62.8	3952	39633	78.8
8 or less	30625	87.2	5926	65.7	4102	40653	80.8
9 or less	31085	88.5	6140	68.2	4185	41410	82.3
10 or less	31467	89.7	6321	70.1	4265	42053	83.7
11 or less	31794	90.4	6454	71.5	4319	42567	84.7
12 or less	32124	91.4	6647	73.7	4405	43176	85.9
13 or less	32326	92.0	6755	74.9	4456	43537	86.6
14 or less	32553	92.7	6884	76.3	4524	43961	87.4
15 or less	32759	93.2	6979	77.4	4573	44311	88.1
20 or less	33384	94.9	7336	81.3	4738	45458	90.4
25 or less	33755	96.1	7604	84.4	4838	46197	91.8
30 or less	33999	96.8	7785	86.3	4912	46696	92.8
35 or less	34152	97.2	7932	88.0	4962	47046	93.6
40 or less	34275	97.5	8034	89.0	5017	47326	94.1
50 or less	34425	98.0	8180	90.8	5087	47692	94.8
75 or less	34613	89.6	8384	92.9	5176	48173	95.8
100 or less	34712	98.8	8481	94.1	5212	48405	96.2
Over 100	229		299		132	660	
No data	193		162		816	1171	
Open head systems	...		74		...	74	
Total	35134		9016		6160	50310	

Table No. 3 — Number of Sprinklers Operating

No. of Fires from 1945-1949 Inclusive

No. of Sprinklers Operating	Wet	%	Dry	%	No Data	Total	%
1	3398	47.2	397	21.0	759	4554	38.9
2	1115	15.5	227	12.0	425	1767	15.1
3	545	7.6	189	10.0	268	1002	8.5
4	372	5.2	120	6.4	168	660	5.6
5	263	3.7	85	4.5	120	468	4.0
6	227	3.2	80	4.2	99	406	3.5
7	141	2.0	58	3.1	80	279	2.4
8	111	1.5	53	2.8	77	241	2.1
9	96	1.3	45	2.4	34	175	1.5
10	72	1.0	33	1.7	31	136	1.2
11	65	0.9	29	1.5	26	120	1.0
12	80	1.1	46	2.4	32	158	1.4
13	47	0.7	18	1.0	27	92	0.8
14	55	0.8	27	1.4	34	116	1.0
15	41	0.6	20	1.1	23	84	0.7
16-20	127	1.8	66	3.5	75	268	2.3
21-25	80	1.1	66	3.5	53	199	1.7
26-30	67	0.9	42	2.2	37	146	1.2
31-35	39	0.5	28	1.5	21	88	0.7
36-40	26	0.4	22	1.2	21	69	0.6
41-50	29	0.4	26	1.4	30	85	0.7
51-75	34	0.5	65	3.4	40	139	1.2
76-100	24	0.3	22	1.2	19	65	0.6
Over 100	57	0.8	68	3.6	48	173	1.5
No data	74	1.0	34	1.8	85	193	1.6
Open head systems	...	...	22	1.2	...	22	0.2
Total	7185	100.0	1888	100.0	2632	11705	100.0

No. of Fires, 1925-1949 Inclusive

	Wet	%	Dry	%	No Data	%	Total	%
1	15281	43.4	1887	20.9	1674	27.2	18842	37.5
2	6499	18.5	1245	13.8	845	13.7	8589	17.1
3	3137	8.9	820	9.1	511	8.3	4468	8.9
4	2064	5.9	636	7.1	352	5.7	3052	6.1
5	1285	3.7	423	4.7	203	3.3	1911	3.8
6	1039	3.0	344	3.8	234	3.8	1617	3.2
7	709	2.0	312	3.5	133	2.2	1154	2.3
8	611	1.7	259	2.9	150	2.4	1020	2.0
9	460	1.3	214	2.4	83	1.4	757	1.5
10	382	1.1	181	2.0	80	1.3	643	1.3
11	327	0.9	133	1.5	54	0.9	514	1.0
12	330	0.9	193	2.1	86	1.4	609	1.2
13	202	0.6	108	1.2	51	0.8	361	0.7
14	227	0.7	129	1.4	68	1.1	424	0.8
15	206	0.6	95	1.1	49	0.8	350	0.7
16-20	625	1.8	357	3.9	165	2.7	1147	2.3
21-25	371	1.1	268	3.0	100	1.6	739	1.5
26-30	244	0.7	181	2.0	74	1.2	499	1.0
31-35	153	0.4	147	1.6	50	0.8	350	0.7
36-40	123	0.4	102	1.1	55	0.9	280	0.6
41-50	150	0.4	146	1.6	70	1.1	366	0.7
51-75	188	0.5	204	2.3	89	1.4	481	0.9
76-100	99	0.3	97	1.1	36	0.6	232	0.5
Over 100	229	0.7	299	3.3	132	2.1	660	1.3
No data	193	0.5	162	1.8	816	13.3	1171	2.3
Open head systems	...	...	74	0.8	...	...	74	0.1
Total	35134	100.0	9016	100.0	6160	100.0	50310	100.0

Table No. 4 — Effect of Sprinklers by Class of Occupancy

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Abrasive Works	28	62.2	14	31.1	42	93.3	3	6.7	45
Agricultural Implements Mfg.	41	61.2	20	29.9	61	91.1	6	8.9	67
Aircraft Hangars	10	62.5	6	37.5	16	100.0	0	0.0	16
Aircraft Mfg.	31	34.5	56	62.2	87	96.7	3	3.3	90
Aluminum Works	17	45.9	17	45.9	34	91.8	3	8.1	37
Amusement Places	38	77.6	8	16.3	46	93.9	3	6.1	49
Apartments (No Mercantiles)	255	83.9	46	15.1	301	99.0	3	1.0	304
Apartments (With Mercantiles)	20	66.7	8	26.6	28	93.3	2	6.7	30
Artificial Flowers, etc., Mfg.	29	72.5	11	27.5	40	100.0	0	0.0	40
Artificial Leather Mfg.	57	58.2	38	38.7	95	96.9	3	3.1	98
Artificial Silk (See Rayon and Artificial Silk Mfg.)									
Asbestos Works	37	45.7	40	49.4	77	95.1	4	4.9	81
Asphalt Works	5	55.6	4	44.4	9	100.0	0	0.0	9
Automobile Body Mfg.	64	56.2	41	35.9	105	92.1	9	7.9	114
Automobile Factories	255	63.0	131	32.3	386	95.3	19	4.7	405
Automobile Paint Shops	16	51.6	14	45.2	30	96.8	1	3.2	31
Auto Sales and Service	99	68.3	40	27.6	139	95.9	6	4.1	145
Bag Factories	58	61.7	29	30.8	87	92.5	7	7.5	94
Bakeries	236	65.5	114	31.7	350	97.2	10	2.8	360
Barns (See Stables and Barns)									
Battery Mfg.	49	59.0	30	36.2	79	95.2	4	4.8	83
Batting Mills (See Waste and Batting Mills)									
Bleaching (See Dyeing, Bleaching and Finishing)									
Bolt and Nut Works	10	41.7	10	41.7	20	83.4	4	16.7	24
Bottle Caps and Seals Mfg.	37	56.1	29	43.9	66	100.0	0	0.0	66
Bottling Works	23	65.7	11	31.4	34	97.1	1	2.9	35
Bowling Alleys	29	78.4	4	10.8	33	89.2	4	10.8	37
Box Factories (Wood)	117	54.7	74	34.6	191	89.3	23	10.7	214
Braid Mills	67	77.0	20	23.0	87	100.0	0	0.0	87
Brass and Copper Works	57	73.1	19	24.3	76	97.4	2	2.6	78
Breweries	17	53.2	15	46.8	32	100.0	0	0.0	32
Brick and Tile Works	6	66.7	2	22.2	8	88.9	1	11.1	9
Broom Factories	34	80.9	6	14.3	40	95.2	2	4.8	42
Brush Factories	31	66.0	15	31.9	46	97.9	1	2.1	47
Builders' Supp. and Equip. Whses.	14	58.3	6	25.0	20	83.3	4	16.7	24
Buildings Under Construction	6	60.0	3	30.0	9	90.0	1	10.0	10
Button Factories	86	84.3	16	15.7	102	100.0	0	0.0	102
Candle Factories	8	80.0	2	20.0	10	100.0	0	0.0	10
Candy Factories	209	65.7	99	31.2	308	96.9	10	3.1	318
Canneries	20	58.8	11	32.4	31	91.2	3	8.8	34
Car Houses	16	48.4	15	45.5	31	93.9	2	6.1	33
Car Works	15	57.7	10	38.5	25	96.2	1	3.8	26
Carbon Works	16	66.7	8	33.3	24	100.0	0	0.0	24
Carpet and Rug Mills	122	58.9	80	38.7	202	97.6	5	2.4	207
Casket Mfg.	59	57.3	38	36.9	97	94.2	6	5.8	103
Cement and Plaster Works	15	79.0	2	10.5	17	89.5	2	10.5	19
Cereal Mills	16	45.7	17	48.6	33	94.3	2	5.7	35
Chemical and Drug Warehouses	8	53.3	7	46.7	15	100 0	0	0.0	15
Chemical Works	314	54.0	238	41.0	552	95.0	29	5.0	581
Churches	7	87.5	1	12.5	8	100.0	0	0.0	8
Clock and Watch Mfg.	25	83.3	5	16.7	30	100.0	0	0.0	30
Clothing Mfg.	1508	82.3	304	16.6	1812	98.9	20	1.1	1832
Clubs (City)	47	83.9	9	16.1	56	100.0	0	0.0	56
Clubs (Country)	69	72.6	24	25.3	93	97.9	2	2.1	95
Coal Sheds	3	21.4	8	57.2	11	78.6	3	21.4	14
Coffee and Spice Mills	92	65.3	47	33.3	139	98.6	2	1.4	141
Cold Storage Warehouses	26	76.5	5	14.7	31	91.2	3	8.8	34
Colleges (See Schools)									

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Cooperage Plants	25	59.5	13	31.0	38	90.5	4	9.5	42
Copper Works (See Brass and Copper Works)									
Cordage Works	88	63.3	44	31.7	132	95.0	7	5.0	139
Cork Plants	44	55.7	31	39.2	75	94.9	4	5.1	79
Cotton Gins	9	56.3	4	25.0	13	81.3	3	18.7	16
Cotton Mills	3736	55.5	2910	43.3	6646	98.9	78	1.2	6724
Cotton Seed Oil Mills	14	31.8	14	31.8	28	63.6	16	36.4	44
Cotton Warehouses	165	42.1	170	43.4	335	85.5	57	14.5	392
Creameries (See Dairies and Creameries)									
Cutlery Mfg.	19	65.5	9	31.0	28	96.5	1	3.5	29
Dairies and Creameries	18	56.3	13	40.6	31	96.9	1	3.1	32
Department Stores	671	81.0	134	16.2	805	97.2	23	2.8	828
Distilleries	18	43.9	19	46.3	37	90.2	4	9.8	41
Doll Factories	80	58.8	56	41.2	136	100.0	0	0.0	136
Door Manufacturing (See Sash, Door and Blind Factories)									
Drug Mfg.	191	75.5	55	21.7	246	97.2	7	2.8	253
Drug Warehouses (See Chemical and Drug Warehouses)									
Dry Cleaning Establishments	60	56.1	44	41.1	104	97.2	3	2.8	107
Dry Goods Stores	261	85.8	36	11.9	297	97.7	7	2.3	304
Dyeing, Bleaching and Finishing	264	60.8	156	36.0	420	96.8	14	3.2	434
Electrical Appliances Mfg.	554	64.3	285	33.1	839	97.4	22	2.6	861
Electrical Equipment Warehouses	10	58.8	6	35.3	16	94.1	1	5.9	17
Electric Power and Light Stations	11	68.7	3	18.8	14	87.5	2	12.5	16
Excelsior Factories	18	48.7	13	35.1	31	83.8	6	16.2	37
Feed Warehouses (See Grain Warehouses)									
Fertilizer Plants	7	46.7	6	40.0	13	86.7	2	13.3	15
Fibre Products Mfg.	45	42.4	52	49.1	97	91.5	9	8.5	106
Fibres Warehouses	5	25.0	10	50.0	15	75.0	5	25.0	20
Film Mfg. (See Photo, Camera and Film Mfg.)									
Fireworks Mfg.	2	28.6	3	42.8	5	71.4	2	28.6	7
Five Cent to $1.00 Stores	73	78.5	18	19.4	91	97.9	2	2.1	93
Flax and Linen Mills	27	64.3	14	33.3	41	97.6	1	2.4	42
Flour and Grist Mills	100	55.5	54	30.0	154	85.5	26	14.5	180
Food Products Mfg. (Misc.)	82	57.8	58	40.8	140	98.6	2	1.4	142
Food Products Warehouses	79	65.8	32	26.7	111	92.5	9	7.5	120
Forges and Smithies	24	54.5	17	38.7	41	93.2	3	6.8	44
Foundries	189	54.2	144	41.2	333	95.4	16	4.6	349
Fur Works	214	84.2	32	12.6	246	96.8	8	3.2	254
Furniture Factories	871	65.8	358	27.1	1229	92.9	94	7.1	1323
Furniture Stores	163	76.2	43	20.1	206	96.3	8	3.7	214
Furniture Warehouses	75	65.8	32	28.1	107	93.9	7	6.1	114
Garages	722	70.7	279	27.3	1001	98.0	20	2.0	1021
Gas Works	3	42.8	3	42.8	6	85.7	1	14.3	7
Gasoline Filling Stations	3	75.0	1	25.0	4	100.0	0	0.0	4
General Storage Warehouses	71	68.3	26	25.0	97	93.3	7	6.7	104
Glass Factories	100	59.5	53	31.6	153	91.1	15	8.9	168
Glove Factories	18	66.7	9	33.3	27	100.0	0	0.0	27
Glucose (See Starch and Glucose)									
Glue Factories	4	25.0	10	62.5	14	87.5	2	12.5	16
Grain Elevators (Country)	16	57.2	9	32.1	25	89.3	3	10.7	28
Grain Elevators (Terminal)	21	56.8	7	18.9	28	75.7	9	24.3	37
Grain, Feed, Seed and Hay Whses.	14	42.4	15	45.5	29	87.9	4	12.1	33
Grist Mills (See Flour and Grist Mills)									
Grocery Stores	213	78.0	52	19.1	265	97.1	8	2.9	273
Gum Mfg.	14	70.0	6	30.0	20	100.0	0	0.0	20
Hair Works	27	64.3	13	30.9	40	95.2	2	4.8	42
Hangars (See Aircraft Hangars)									
Hardware Stores	93	71.0	35	26.7	128	97.7	3	2.3	131
Hardware Warehouses	11	64.7	5	29.4	16	94.1	1	5.9	17

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Hardwood Turning	123	53.5	84	36.5	207	90.0	23	10.0	230
Hat Factories	423	83.3	79	15.5	502	98.8	6	1.2	508
Hay Warehouses (See Grain Warehouses)									
Hospitals	78	79.6	17	17.3	95	96.9	3	3.1	98
Hotels (Seasonal)	59	78.7	12	16.0	71	94.7	4	5.3	75
Hotels (Year Round)	215	82.0	41	15.7	256	97.7	6	2.3	262
Ice Mfg.	4	50.0	3	37.5	7	87.5	1	12.5	8
Ice Cream Mfg.	8	61.5	5	38.5	13	100.0	0	0.0	13
Idle and Vacant Property	55	50.5	24	22.0	79	72.5	30	27.5	109
Incandescent Lamp Works	12	80.0	3	20.0	15	100.0	0	0.0	15
Institutions	30	93.7	2	6.3	32	100.0	0	0.0	32
Insulated Wire Mfg.	61	61.6	32	32.3	93	93.9	6	6.1	99
Interior Woodwork Mfg.	153	55.7	88	32.0	241	87.7	34	12.3	275
Iron Converting Plants (See Steel and Iron Converting Plants)									
Jewelry Factories	136	78.1	35	20.1	171	98.2	3	1.8	174
Junk Shops	34	61.8	16	29.1	50	90.9	5	9.1	55
Knitting Mills (Cop Yarn)	49	72.0	18	26.5	67	98.5	1	1.5	68
Knitting Mills (Full Process)	291	78.0	72	19.3	363	97.3	10	2.7	373
Lampshade Factories	63	86.3	8	11.0	71	97.3	2	2.7	73
Laundries	298	67.4	132	29.9	430	97.3	12	2.7	442
Leather, Leather Products Whses.	14	82.4	3	17.6	17	100.0	0	0.0	17
Leather Tanneries (Misc.)	14	56.0	6	24.0	20	80.0	5	20.0	25
Leather Tanneries (Sole, Belting)	33	53.2	22	35.5	55	88.7	7	11.3	62
Leather Tanneries (Upper)	129	64.5	62	31.0	191	95.5	9	4.5	200
Leather Working	290	75.7	85	22.2	375	97.9	8	2.1	383
Linen Mills (See Flax and Linen Mills)									
Linoleum Works	41	37.3	60	54.5	101	91.8	9	8.2	110
Linseed Oil Works	16	48.5	9	27.3	25	75.8	8	24.2	33
Liquor Warehouses	6	46.1	3	23.1	9	69.2	4	30.8	13
Lithographing (See Printing and Lithographing)									
Lumber Sheds	28	40.0	33	47.1	61	87.1	9	12.9	70
Macaroni Factories	12	50.0	11	45.8	23	95.8	1	4.2	24
Machine Shops	372	67.1	170	30.7	542	97.8	12	2.2	554
Magnesium Works	3	27.3	7	63.6	10	90.9	1	9.1	11
Mail Order Houses	42	82.3	9	17.7	51	100.0	0	0.0	51
Match Factories	54	75.0	15	20.8	69	95.8	3	4.2	72
Mattress Factories	534	69.7	212	27.6	746	97.3	21	2.7	767
Mercantiles (Misc.)	857	82.6	153	14.7	1010	97.3	28	2.7	1038
Mercantile Stock Warehouses	23	58.9	15	38.5	38	97.4	1	2.6	39
Metal Beds Mfg.	51	51.5	37	37.4	88	88.9	11	11.1	99
Metals Warehouses	16	45.7	16	45.7	32	91.4	3	8.6	35
Metalworkers (Heavy)	225	54.0	177	42.4	402	96.4	15	3.6	417
Metalworkers (Light)	557	59.3	359	38.2	916	97.5	23	2.5	939
Metalworkers (Misc.)	140	46.6	152	50.7	292	97.3	8	2.7	300
Mining Property	24	68.5	8	22.9	32	91.4	3	8.6	35
Miscellaneous	73	67.6	22	20.4	95	88.0	13	12.0	108
Mirror Mfg.	24	82.7	4	13.8	28	96.5	1	3.5	29
Motion Picture Exchanges	45	65.2	20	29.0	65	94.2	4	5.8	69
Motion Picture Studios	86	71.1	32	26.4	118	97.5	3	2.5	121
Motion Picture Theatres	86	74.2	23	19.8	109	94.0	7	6.0	116
Multiple Occupancies (See also Tenant Mfg.; Apartments with Mercantiles)	819	76.5	210	19.6	1029	96.1	42	3.9	1071
Multiple Occupancy Warehouses	36	64.3	8	14.3	44	78.6	12	21.4	56
Munitions	17	51.5	13	39.4	30	90.9	3	9.1	33
Musical Instruments Factories	69	83.1	13	15.7	82	98.8	1	1.2	83
Office Buildings	168	81.9	33	16.1	201	98.0	4	2.0	205
Oil Cloth Mfg.	20	54.1	17	45.9	37	100.0	0	0.0	37

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Oil Clothing Mfg.	9	56.2	6	37.5	15	93.7	1	6.3	16
Oil Refineries (Animal)	8	66.7	2	16.7	10	83.4	2	16.7	12
Oil Refineries (Mineral)	11	64.7	5	29.4	16	94.1	1	5.9	17
Oil Refineries (Vegetable)	26	62.0	19	38.0	45	90.0	5	10.0	50
Optical Works	47	63.5	27	36.5	74	100.0	0	0.0	74
Packing Plants (Fruit and Veg.)	15	68.2	7	31.8	22	100.0	0	0.0	22
Packing Houses (Meat)	137	60.6	79	35.0	216	95.6	10	4.4	226
Pails and Woodenware Mfg.	23	47.9	21	43.8	44	91.7	4	8.3	48
Paint Shops	14	70.0	5	25.0	19	95.0	1	5.0	20
Paint and Varnish Works	263	59.3	160	36.0	423	95.3	21	4.7	444
Paper Coating Mills	48	57.8	30	36.2	78	94.0	5	6.0	83
Paper Mills	609	48.7	563	45.1	1172	93.8	77	6.2	1249
Paper Warehouses	54	68.4	17	21.5	71	89.9	8	10.1	79
Paper Working	522	64.0	269	32.9	791	96.9	25	3.1	816
Patent Leather Mfg.	13	56.5	8	34.8	21	91.3	2	8.7	23
Peanut Plants	7	38.9	5	27.8	12	66.7	6	33.3	18
Phonograph Works	19	61.3	11	35.5	30	96.8	1	3.2	31
Photo Camera and Film Mfg.	46	66.7	23	33.3	69	100.0	0	0.0	69
Photo Engraving and Studios	76	88.4	10	11.6	86	100.0	0	0.0	86
Picture Frame Mfg.	31	72.1	12	27.9	43	100.0	0	0.0	43
Piers and Wharves	41	58.6	23	32.8	64	91.4	6	8.6	70
Planing Mills (See Saw and Planing Mills)									
Plaster Works (See Cement and Plaster Works)									
Plastics Fabricating	1	50.0	1	50.0	2	100.0	0	0.0	2
Plastics Mfg.	15	46.8	12	37.5	27	84.3	5	15.7	32
Plumbers Supplies Mfg.	24	64.8	10	27.1	34	91.9	3	8.1	37
Potteries	19	57.6	11	33.3	30	90.9	3	9.1	33
Printing and Lithographing	974	81.7	202	17.0	1176	98.7	16	1.3	1192
Prisons	13	59.1	8	36.4	21	95.5	1	4.5	22
Public Buildings	24	80.0	3	10.0	27	90.0	3	10.0	30
Public Household Furniture Whses.	16	69.6	6	26.1	22	95.7	1	4.3	23
Pulp Mills	24	47.0	21	41.2	45	88.2	6	11.8	51
Pyroxylin Mfg.	40	67.8	13	22.0	53	89.8	6	10.2	59
Pyroxylin Novelties Mfg.	135	74.2	41	22.5	176	96.7	6	3.3	182
Pyroxylin Scrap Reclaiming, Stge.	47	54.7	29	33.7	76	88.4	10	11.6	86
Radios and Accessories Mfg.	104	70.3	39	26.3	143	96.6	5	3.4	148
Railroad Misc. Property	24	70.6	9	26.5	33	97.1	1	2.9	34
Railroad Repair Shops	4	28.6	10	71.4	14	100.0	0	0.0	14
Rayon and Artificial Silk Mfg.	50	55.5	32	35.6	82	91.1	8	8.9	90
Research Laboratories (See Scientific and Research Laboratories)									
Restaurants	303	72.8	109	26.2	412	99.0	4	1.0	416
Rice Mills	3	23.1	5	38.5	8	61.5	5	38.5	13
Rolling and Plate Mills	104	58.1	70	39.1	174	97.2	5	2.8	179
Roofing Mfg.	58	30.5	121	63.7	179	94.2	11	5.8	190
Rooming Houses	10	83.3	1	8.3	11	91.7	1	8.3	12
Rubber Cloth Factories	112	66.7	51	30.3	163	97.0	5	3.0	168
Rubber Mills	363	54.7	276	41.7	639	96.4	25	3.8	664
Rubber Reclaiming	31	54.4	17	29.8	48	84.2	9	15.8	57
Rubber Warehouses	12	80.0	3	20.0	15	100.0	0	0.0	15
Rug Mills (See Carpet and Rug Mills)									
Sash, Door and Blind Factories	89	53.3	65	38.9	154	92.2	13	7.8	167
Saw and Planing Mills	67	37.0	60	33.2	127	70.2	54	29.8	181
Schools (Colleges and Universities)	34	73.9	9	19.6	43	93.5	3	6.5	46
Schools (Private)	27	73.0	10	27.0	37	100.0	0	0.0	37
Schools (Public)	18	62.0	8	27.6	26	89.6	3	10.4	29
Schools (Trade)	14	73.7	3	15.8	17	89.5	2	10.5	19
Scientific and Research Laboratories	17	70.8	7	29.2	24	100.0	0	0.0	24
Seed Warehouses (See Grain Warehouses)									
Sheet Metal Works (See Stamping and Sheet Metal Works)									
Shipyards	28	54.9	18	35.3	46	90.2	5	9.8	51

	Extinguished Fire		Held Fire in Check		Total Satisfactory		Unsatisfactory		Total No. of Fires
	No.	%	No.	%	No.	%	No.	%	
Shoddy Mills	123	55.7	86	38.9	209	94.6	12	5.4	221
Shoe Accessories Mfg.	77	68.1	27	23.9	104	92.0	9	8.0	113
Shoe Factories	858	76.9	225	20.1	1083	97.0	34	3.0	1117
Shoe Last Mfg. (See Wooden Heel and Shoe Last Factories)									
Shoe Stores	79	87.8	11	12.2	90	100.0	0	0.0	90
Silk Mills	141	83.9	22	13.1	163	97.0	5	3.0	168
Skin Mills	28	60.8	14	30.5	42	91.3	4	8.7	46
Smelting and Refining	8	50.0	7	43.7	15	93.7	1	6.3	16
Smithies (See Forges and Smithies)									
Soap Mfg.	43	56.5	29	38.2	72	94.7	4	5.3	76
Soybean Milling and Refining	3	23.1	6	46.2	9	69.3	4	30.7	13
Spice Mills (See Coffee and Spice Mills)									
Stables and Barns	12	66.7	5	27.8	17	94.5	1	5.5	18
Stamping and Sheet Metal Works	223	54.0	177	42.8	400	96.8	13	3.2	413
Starch and Glucose Mfg.	9	64.3	4	28.6	13	92.9	1	7.1	14
Steel and Iron Converting Plants	10	71.4	4	28.6	14	100.0	0	0.0	14
Stone Working	9	75.0	2	16.7	11	91.7	1	8.3	12
Stove Works	58	65.9	25	28.4	83	94.3	5	5.7	88
Structural Iron and Steel Works	42	52.5	36	45.0	78	97.5	2	2.5	80
Studios (See Photo Engraving and Studios)									
Sugar Refineries	29	43.9	34	51.6	63	95.5	3	4.5	66
Telephone Exchanges	6	85.7	1	14.3	7	100.0	0	0.0	7
Tenant Mfg.	2902	76.2	790	20.7	3692	96.9	119	3.1	3811
Terminal Warehouses	33	52.4	24	38.1	57	90.5	6	9.5	63
Textile Warehouses	12	57.2	6	28.5	18	85.7	3	14.3	21
Theatres	70	77.7	15	16.7	85	94.4	5	5.6	90
Tile Works (See Brick and Tile Works)									
Tobacco Factories	57	68.7	23	27.7	80	96.4	3	3.6	83
Tobacco Warehouses	21	65.6	8	25.0	29	90.6	3	9.4	32
Toy Mfg. (Wood and Metal)	16	48.5	17	51.5	33	100.0	0	0.0	33
Trunk Factories	32	78.0	3	7.3	35	85.3	6	14.7	41
Tube Factories (See Wire and Tube Works)									
Umbrella Mfg.	22	73.3	7	23.4	29	96.7	1	3.3	30
Universities (See Schools)									
Upholstering	19	59.4	13	40.6	32	100.0	0	0.0	32
Vacant Property (See Idle and Vacant Property)									
Varnish Works (See Paint and Varnish Works)									
Wall Paper Factories	15	75.0	5	25.0	20	100.0	0	0.0	20
Warehouses (Miscellaneous)	100	64.1	47	30.1	147	94.2	9	5.8	156
Waste and Batting Mills	254	58.9	150	34.8	404	93.7	27	6.3	431
Waste Paper and Rag Shops	393	63.2	198	31.8	591	95.0	31	5.0	622
Waste Warehouses	14	45.2	14	45.2	28	90.3	3	9.7	31
Watch Mfg. (See Clock and Watch Mfg.)									
Water Works	1	50.0	1	50.0	2	100.0	0	0.0	2
Weaving Mills	417	76.7	121	22.3	538	99.0	5	0.9	543
Wharves (See Piers and Wharves)									
Wholesale Mercantiles	17	89.5	2	10.5	19	100.0	0	0.0	19
Window Shade Mfg.	16	69.5	6	26.1	22	95.6	1	4.4	23
Wire and Tube Works	4	30.8	8	61.5	12	92.3	1	7.7	13
Wooden Heel and Shoe Last Mfg.	89	78.1	22	19.3	111	97.4	3	2.6	114
Wood Flour Mills	7	28.0	14	56.0	21	84.0	4	16.0	25
Wood and Wood Products Whses.	7	53.8	6	46.2	13	100.0	0	0.0	13
Woodworkers (Misc.)	260	56.6	172	37.5	432	94.1	27	5.9	459
Wool Scouring Plants	37	64.9	15	26.3	52	91.2	5	8.8	57
Woolen Mills	628	67.2	265	28.4	893	95.6	41	4.4	934
Wool Warehouses	10	50.0	7	35.0	17	85.0	3	15.0	20
Worsted Mills	66	75.0	20	22.7	86	97.7	2	2.3	88
Total	33132		15204		48336		1974		50310

SECTION II

Table No. 1 — Classification of Unsatisfactory Sprinkler Fires by Occupancy

	Water to Sprinklers Shut Off	Partial Protection	Inadequate Water Supplies	System Frozen	Slow Operation	Defective Dry Pipe Valve	Faulty Building Construction	Obstruction to Distribution	Hazard of Occupancy	Exposure Fire	Inadequate Maintenance	Antiquated Systems	Miscellaneous and Unknown	Total
Abrasive Works	1	..	..	..	..	..	1	..	..	..	1	..	..	3
Agricultural Implements Mfg.	3	..	..	..	..	..	1	1	1	..	..	..	..	6
Aircraft Mfg.	1	..	..	..	..	..	..	..	1	..	..	1	..	3
Aluminum Works	..	..	..	..	..	..	..	..	3	..	..	..	..	3
Amusement Places	2	..	..	..	..	..	..	..	..	..	1	..	..	3
Apartments (No Mercantiles)	..	2	..	..	..	..	..	1	..	..	..	..	..	3
Apartments (With Merc.)	1	..	..	..	..	..	..	..	1	..	..	..	..	2
Artificial Leather Mfg.	..	..	..	..	..	..	1	..	2	..	..	..	..	3
Asbestos Works	3	1	..	..	..	..	..	..	..	..	..	..	..	4
Automobile Body Mfg.	..	2	..	..	..	..	..	2	1	1	3	..	..	9
Automobile Factories	4	4	1	..	..	..	..	1	4	..	4	..	1	19
Automobile Paint Shops	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Auto Sales and Service	4	..	1	..	..	..	..	..	1	..	..	..	..	6
Bag Factories	4	..	..	..	..	..	..	1	..	..	2	..	..	7
Bakeries	3	..	..	..	..	..	1	4	1	..	1	..	..	10
Battery Mfg.	2	..	1	..	..	..	..	..	..	..	1	..	..	4
Bolt and Nut Works	1	1	..	..	..	..	1	..	..	..	..	1	..	4
Bottling Works	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Bowling Alleys	2	1	..	..	..	..	1	..	..	..	..	..	..	4
Box Factories (Wood)	7	2	5	1	1	1	..	..	4	1	..	1	..	23
Brass and Copper Works	1	..	..	..	..	..	..	1	..	..	..	..	..	2
Brick and Tile Works	..	..	..	..	..	..	..	..	..	..	..	1	..	1
Broom Factories	1	..	1	..	..	..	..	..	..	..	..	..	..	2
Brush Factories	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Builders' Supplies, Equip. Whses.	3	..	1	..	..	..	..	..	..	..	..	..	..	4
Buildings Under Construction	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Candy Factories	4	1	..	..	..	..	1	..	1	1	2	..	..	10
Canneries	1	..	1	..	..	..	1	..	..	..	..	..	..	3
Car Houses	..	1	..	..	..	..	..	..	..	..	1	..	..	2
Car Works	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Carpet and Rug Mills	1	..	..	..	2	..	..	1	..	..	..	..	1	5
Casket Mfg.	2	..	1	..	..	1	1	..	..	..	..	..	1	6
Cement and Plaster Works	1	1	..	..	..	..	..	..	..	..	..	..	..	2
Cereal Mills	1	..	..	..	..	..	..	..	1	..	..	..	..	2
Chemical Works	2	2	3	..	1	..	..	2	16	..	3	..	..	29
Clothing Mfg.	10	1	1	..	..	..	2	2	..	1	2	..	1	20
Clubs (Country)	1	1	..	..	..	..	..	..	..	..	..	..	..	2
Coal Sheds	3	..	..	..	..	..	..	..	..	..	..	..	..	3
Coffee and Spice Mills	..	2	..	..	..	..	..	..	..	..	..	..	..	2
Cold Storage Warehouses	1	..	..	1	..	..	..	..	1	..	..	..	..	3
Cooperage Plants	..	2	..	..	..	..	1	..	..	1	..	..	..	4
Cordage Works	2	..	1	..	..	..	..	1	1	..	1	1	..	7
Cork Plants	..	..	1	..	..	..	1	..	2	..	..	..	..	4
Cotton Gins	2	1	..	..	..	..	..	..	..	..	..	..	..	3
Cotton Mills	26	2	5	..	2	1	1	7	8	..	18	3	5	78
Cotton Seed Oil Mills	4	..	6	..	..	..	..	..	1	1	..	3	1	16
Cotton Warehouses	13	2	10	1	3	2	1	12	1	..	11	1	..	57
Cutlery Mfg.	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Dairies and Creameries	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Department Stores	11	1	1	..	..	1	4	3	..	..	1	1	..	23
Distilleries	..	..	..	..	..	..	..	..	3	..	..	1	..	4
Drug Mfg.	4	1	..	..	..	1	..	..	1	..	..	..	..	7

	Water to Sprinklers Shut Off	Partial Protection	Inadequate Water Supplies	System Frozen	Slow Operation	Defective Dry Pipe Valve	Faulty Building Construction	Obstruction to Distribution	Hazard of Occupancy	Exposure Fire	Inadequate Maintenance	Antiquated Systems	Miscellaneous and Unknown	Total
Dry Cleaning Establishments	1	..	..	..	..	..	..	..	1	..	1	..	..	3
Dry Goods Stores	6	..	..	..	..	..	1	..	..	..	..	..	..	7
Dyeing, Bleaching, Finishing	7	..	..	..	1	..	1	3	..	..	2	..	..	14
Electrical Appliance Mfg.	6	1	1	..	2	..	2	5	3	..	2	..	..	22
Electrical Equipment Whses.	..	..	..	..	..	1	..	..	..	..	..	..	..	1
Electric Power and Light Sta.	2	..	..	..	..	..	..	..	..	..	..	..	..	2
Excelsior Factories	..	..	3	..	1	1	..	..	1	..	..	..	..	6
Fertilizer Plants	..	..	..	..	..	..	..	..	2	..	..	..	..	2
Fibre Products	2	..	1	..	..	1	..	3	1	..	1	..	..	9
Fibres Warehouses	1	..	..	..	..	..	..	3	1	..	..	..	..	5
Fireworks Mfg.	..	..	..	..	..	..	..	..	2	..	..	..	..	2
Five Cent to $1.00 Stores	..	..	..	..	..	..	2	..	..	..	..	..	..	2
Flax and Linen Mills	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Flour and Grist Mills	6	3	1	..	..	..	1	..	9	1	1	..	4	26
Food Products Mfg. (Misc.)	..	..	..	..	..	..	..	1	1	..	..	..	..	2
Food Products Warehouses	5	1	1	..	..	1	..	..	1	..	..	..	..	9
Forges and Smithies	..	..	1	..	..	..	..	..	1	..	1	..	..	3
Foundries	9	..	..	1	..	1	..	2	..	..	1	2	..	16
Fur Works	2	..	..	..	2	..	..	2	..	..	..	1	1	8
Furniture Factories	32	8	11	1	3	4	8	2	17	1	3	2	2	94
Furniture Stores	5	..	..	..	..	..	2	..	..	..	1	..	..	8
Furniture Warehouses	4	..	..	..	..	1	..	..	1	..	1	..	..	7
Garages	12	1	..	2	..	1	..	1	2	..	1	..	..	20
Gas Works	..	..	..	..	..	..	..	..	..	..	..	1	..	1
General Storage Warehouses	1	..	2	..	..	..	1	..	1	1	..	1	..	7
Glass Factories	6	..	1	1	..	..	2	1	3	..	1	..	..	15
Glue Factories	1	..	..	..	..	..	..	..	1	..	..	..	..	2
Grain Elevators (Country)	1	..	..	..	1	..	..	..	1	..	..	..	..	3
Grain Elevators (Terminal)	2	..	..	..	..	..	..	..	5	..	..	2	..	9
Grain, Feed, Seed, Hay Whses.	1	1	1	1	..	..	..	..	..	..	..	..	..	4
Grocery Stores	4	..	..	..	1	..	2	..	1	..	..	..	..	8
Hair Works	1	..	..	..	..	..	..	..	1	..	..	..	..	2
Hardware Stores	2	..	..	..	..	..	..	..	1	..	..	..	..	3
Hardware Warehouses	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Hardwood Turning	8	..	1	..	..	..	4	1	3	1	3	1	1	23
Hat Factories	2	..	..	..	..	..	1	1	1	..	1	..	..	6
Hospitals	1	..	..	..	..	..	1	..	..	..	..	1	..	3
Hotels (Seasonal)	..	..	..	1	..	..	2	..	..	..	..	1	..	4
Hotels (Year Round)	4	..	..	..	..	..	1	..	..	..	..	1	..	6
Ice Mfg.	..	..	..	..	..	..	1	..	..	..	..	..	..	1
Idle and Vacant Property	25	..	..	..	..	..	..	1	1	1	1	..	1	30
Insulated Wire Mfg.	3	1	..	..	1	..	..	1	..	..	..	..	..	6
Interior Woodwork Mfg.	8	4	7	1	3	1	2	3	3	..	2	..	..	34
Jewelry Factories	2	..	..	..	..	1	..	..	..	..	..	..	..	3
Junk Shops	3	..	..	..	1	..	..	..	..	1	..	..	..	5
Knitting Mills (Cop Yarn)	..	..	..	..	..	..	..	..	..	..	1	..	..	1
Knitting Mills (Full Process)	7	..	..	..	..	1	..	..	..	..	2	..	..	10
Lampshade Factories	..	1	1	..	..	..	..	..	..	..	..	..	..	2
Laundries	7	1	1	..	..	..	2	..	1	..	..	..	..	12
Leather Tanneries (Misc.)	4	..	..	..	..	..	..	..	..	..	..	..	1	5
Leather Tan. (Sole, Belting)	2	..	1	..	..	..	1	..	1	1	..	1	..	7
Leather Tanneries (Upper)	5	1	..	..	..	2	1	..	..	..	..	..	..	9
Leather Working	3	..	1	..	..	..	..	1	2	..	1	..	..	8
Linoleum Works	..	1	1	..	1	..	2	1	2	..	..	..	1	9

	Water to Sprinklers Shut Off	Partial Protection	Inadequate Water Supplies	System Frozen	Slow Operation	Defective Dry Pipe Valve	Faulty Building Construction	Obstruction to Distribution	Hazard of Occupancy	Exposure Fire	Inadequate Maintenance	Antiquated Systems	Miscellaneous and Unknown	Total
Linseed Oil Works	1	..	..	..	..	..	1	1	3	..	1	1	..	8
Liquor Warehouses	2	..	..	..	..	..	1	..	1	..	..	..	..	4
Lumber Sheds	..	3	1	..	1	..	1	..	1	1	..	..	1	9
Macaroni Factories	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Machine Shops	6	..	1	..	..	..	..	..	2	..	3	..	..	12
Magnesium Works	..	..	..	..	..	..	..	..	1	..	..	..	..	1
Match Factories	1	..	..	..	..	..	..	1	1	..	..	..	..	3
Mattress Factories	16	..	1	..	..	..	..	3	..	..	..	..	1	21
Mercantile (Misc.)	14	1	..	..	1	..	6	2	1	1	2	..	..	28
Mercantile Stock Warehouses	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Metal Beds Mfg.	3	2	1	..	..	1	..	2	2	..	..	..	..	11
Metal Warehouses	1	..	2	..	..	..	..	..	..	..	..	..	..	3
Metalworkers (Heavy)	3	1	1	..	..	..	2	1	4	..	3	..	..	15
Metalworkers (Light)	7	1	1	..	1	1	..	6	2	1	3	..	..	23
Metalworkers (Misc.)	1	..	1	..	..	..	1	2	2	..	..	1	..	8
Mining Property	3	..	..	..	..	..	..	..	..	..	..	..	..	3
Mirror Mfg.	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Miscellaneous	6	..	..	..	..	..	1	..	3	..	2	..	1	13
Motion Picture Exchanges	..	..	..	..	..	1	..	..	3	..	..	..	..	4
Motion Picture Studios	..	1	..	..	..	..	..	..	2	..	..	..	..	3
Motion Picture Theatres	1	3	..	..	..	..	1	..	..	1	1	..	..	7
Multiple Occupancies	15	1	2	4	..	2	11	3	4	..	..	..	..	42
Multiple Occupancy Whses.	6	2	1	..	..	..	1	1	..	..	1	..	..	12
Munitions	..	..	..	..	..	..	..	..	3	..	..	..	..	3
Musical Instruments Factories	..	..	..	..	..	..	..	..	..	..	..	1	..	1
Office Buildings	2	..	..	..	..	..	..	..	1	..	..	1	..	4
Oil Clothing Mfg.	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Oil Refineries (Animal)	..	1	..	..	..	..	..	..	1	..	..	..	..	2
Oil Refineries (Mineral)	..	..	..	..	1	..	..	..	..	..	..	..	..	1
Oil Refineries (Vegetable)	2	..	..	..	..	..	..	..	1	1	1	..	..	5
Packing Houses	9	..	..	..	..	..	..	..	1	..	..	..	..	10
Pails and Woodenware Mfg.	..	2	..	..	..	..	1	1	..	..	..	..	..	4
Paint Shops	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Paint and Varnish Works	5	..	3	..	1	1	..	..	9	..	1	..	1	21
Paper Coating Mills	1	..	..	..	..	..	..	2	1	..	..	1	..	5
Paper Mills	27	2	14	..	1	..	3	12	5	1	9	2	1	77
Paper Warehouses	3	..	..	..	..	1	..	2	..	..	2	..	..	8
Paper Working	6	..	2	..	..	..	2	8	1	..	5	1	..	25
Patent Leather Mfg.	1	..	..	..	..	..	..	..	..	1	..	..	..	2
Peanut Plants	3	..	..	..	1	..	..	..	..	2	..	..	..	6
Phonograph Works	1	..	..	..	..	..	..	..	..	..	..	..	..	1
Piers and Wharves	1	3	..	..	..	..	..	..	1	1	..	..	..	6
Plastics Mfg.	2	..	..	..	..	..	..	1	2	..	..	..	..	5
Plumbers Supplies Mfg.	2	1	..	..	..	..	..	..	..	..	..	..	..	3
Potteries	2	1	..	..	..	..	..	..	..	..	..	..	..	3
Printing and Lithographing	8	2	..	..	..	1	3	1	..	..	1	..	..	16
Prisons	..	..	..	..	..	..	..	..	1	..	..	..	..	1
Public Buildings	..	..	1	..	..	1	..	..	..	..	1	..	..	3
Public Hhld. Furn. Whses.	..	..	..	..	..	..	..	..	1	..	..	..	..	1
Pulp Mills	4	1	..	..	..	..	..	..	..	..	1	..	..	6
Pyroxylin Mfg.	..	..	..	..	..	..	..	..	6	..	..	..	..	6
Pyroxylin Novelties Mfg.	4	..	..	..	..	..	..	..	2	..	..	..	..	6
Pyroxylin Scrap Recl., Stge.	..	..	..	..	..	..	..	..	9	1	..	..	..	10
Radios and Accessories	3	..	..	..	1	..	..	1	..	..	..	..	..	5
Railroad Misc. Property	..	..	..	..	..	..	..	..	1	..	..	..	..	1

	Water to Sprinklers Shut Off	Partial Protection	Inadequate Water Supplies	System Frozen	Slow Operation	Defective Dry Pipe Valve	Faulty Building Construction	Obstruction to Distribution	Hazard of Occupancy	Exposure Fire	Inadequate Maintenance	Antiquated Systems	Miscellaneous and Unknown	Total	Total
Rayon and Artificial Silk Mfg.	2	..	1	..	..	..	..	2	1	..	1	..	1	8	8
Restaurants	1	..	..	..	..	..	3	..	..	..	..	..	..	4	4
Rice Mills	1	..	1	..	..	..	..	1	..	..	..	1	1	5	9
Rolling and Plate Mills	1	..	..	..	..	..	..	1	1	1	1	..	..	5	1
Roofing Mfg.	1	1	2	..	..	..	..	3	1	..	1	..	2	11	12
Rooming Houses	1	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Rubber Cloth Factories	3	..	..	..	..	..	..	1	..	..	1	..	..	5	3
Rubber Mills	8	1	..	..	..	1	..	3	9	..	3	..	..	25	21
Rubber Reclaiming	2	1	1	..	..	..	..	2	2	1	..	..	..	9	28
Sash, Door and Blind Factories	4	2	..	..	..	1	1	1	1	..	1	2	..	13	1
Saw and Planing Mills	14	9	9	2	4	..	1	4	8	..	1	2	..	54	11
Schools (Colleges and Univ.)	1	1	..	..	..	..	..	..	..	..	..	1	..	3	3
Schools (Public)	1	1	..	..	..	..	1	..	..	..	..	..	..	3	15
Schools (Trade)	1	..	1	..	..	..	..	..	..	..	..	..	..	2	23
Shipyards	3	..	2	..	..	..	..	..	..	..	..	..	..	5	8
Shoddy Mills	1	..	2	1	..	1	1	2	1	..	1	2	..	12	3
Shoe Accessories Mfg.	4	1	..	1	..	..	..	..	1	..	..	2	..	9	1
Shoe Factories	8	2	..	1	1	1	3	5	3	1	5	3	1	34	13
Silk Mills	3	..	..	..	..	..	..	..	1	..	1	..	..	5	4
Skin Mills	..	..	..	1	1	1	1	..	..	..	..	..	..	4	3
Smelting and Refining	..	1	..	..	..	..	..	..	..	..	..	..	..	1	7
Soap Mfg.	3	..	..	..	..	..	..	..	..	1	..	..	..	4	42
Soy Bean Milling and Refining	2	1	1	..	..	..	..	..	..	..	..	..	..	4	12
Stables and Barns	1	..	..	..	..	..	..	..	..	..	..	..	..	1	3
Stamping, Sheet Metal Wks.	4	3	2	..	1	..	..	1	1	..	1	..	..	13	1
Starch and Glucose	..	..	..	..	..	..	..	..	1	..	..	..	..	1	4
Stone Working	1	..	..	..	..	..	..	..	..	..	..	..	..	1	1
Stove Works	1	2	..	..	..	..	..	..	1	..	1	..	..	5	2
Structural Iron, Steel Wks.	..	..	..	..	..	..	..	1	..	..	..	..	1	2	1
Sugar Refineries	1	..	..	..	..	..	..	1	..	..	1	..	..	3	5
Tenant Mfg.	66	6	3	3	1	..	7	5	7	3	12	5	1	119	10
Terminal Warehouses	3	..	..	..	..	..	..	1	1	1	..	..	..	6	4
Textile Warehouses	1	..	..	..	..	..	..	2	..	..	..	..	..	3	1
Theatres	4	..	..	..	..	..	1	..	..	..	..	..	..	5	21
Tobacco Factories	..	..	1	..	..	..	1	..	..	..	1	..	..	3	5
Tobacco Warehouses	..	..	1	..	..	..	1	..	..	1	..	..	..	3	77
Trunk Factories	3	..	1	..	..	..	1	..	..	1	..	..	..	6	8
Umbrella Mfg.	..	..	..	..	..	..	..	..	1	..	..	..	..	1	25
Warehouses (Miscellaneous)	3	1	2	..	..	..	1	1	..	..	1	..	..	9	2
Waste and Batting Mills	14	1	2	..	1	..	1	2	1	..	4	..	1	27	6
Waste Paper and Rag Shops	11	..	..	2	1	..	1	6	5	1	3	..	1	31	1
Waste Warehouses	1	..	1	..	..	..	..	..	..	..	1	..	..	3	6
Weaving Mills	..	..	1	..	..	..	..	3	..	..	1	..	..	5	5
Window Shade Mfg.	..	..	..	..	..	..	..	..	1	..	..	..	..	1	3
Wire and Tube Works	..	..	..	..	..	..	..	..	..	..	1	..	..	1	3
Wooden Heel and Last Mfg.	2	..	..	..	..	..	..	..	..	..	1	..	..	3	16
Wood Flour Mills	..	..	..	..	..	..	..	..	4	..	..	..	..	4	1
Woodworkers (Misc.)	9	1	5	..	1	..	1	2	4	1	1	2	..	27	3
Wool Scouring Plants	1	..	1	..	..	..	1	1	..	..	1	..	..	5	1
Woolen Mills	14	2	7	..	1	..	1	4	3	..	6	3	..	41	6
Wool Warehouses	2	..	..	..	..	..	..	..	1	..	..	..	..	3	6
Worsted Mills	..	1	..	..	..	..	..	..	..	..	1	..	..	2	10
Total	726	121	155	26	46	37	123	176	264	36	169	59	36	1974	5 1

SECTION III

Table No. 1 — Sprinkler Performance by Occupancy Groups

Occupancy Group	Extinguished Fire No.	Extinguished Fire %	Held Fire in Check No.	Held Fire in Check %	Total Satisfactory No.	Total Satisfactory %	Unsatisfactory No.	Unsatisfactory %	Total No. of Fires
Residential	560	81.7	108	15.8	668	97.5	17	2.5	685
Assembly	439	75.4	114	19.6	553	95.0	29	5.0	582
Institutional	121	79.6	27	17.8	148	97.4	4	2.6	152
Offices	192	81.7	36	15.3	228	97.0	7	3.0	235
Mercantile	2835	79.4	647	18.2	3482	97.6	86	2.4	3568
Manufacturing									
Chemicals and Chemical Products	1415	57.2	896	36.2	2311	93.4	163	6.6	2474
Fibre Products	198	59.3	117	35.0	315	94.3	19	5.7	334
Food Products	1047	60.7	595	34.5	1642	95.2	83	4.8	1725
Glass Products	171	63.1	84	31.0	255	94.1	16	5.9	271
Leather Working	1531	72.7	490	23.2	2021	95.9	87	4.1	2108
Metal and Metal Products	3550	60.1	2148	36.4	5698	96.5	204	3.5	5902
Mineral Products	138	59.0	79	33.7	217	92.7	17	7.3	234
Paper and Paper Products	1687	57.5	1102	37.7	2789	95.2	140	4.8	2929
Printing and Engraving	1050	82.1	212	16.6	1262	98.7	16	1.3	1278
Rubber and Rubber Products	506	56.9	344	38.7	850	95.6	39	4.4	889
Tenant Mfg.	2902	76.2	790	20.7	3692	96.9	119	3.1	3811
Textiles and Textile Products	9169	64.5	4751	33.5	13920	98.0	285	2.0	14205
Woodworking	2016	58.8	1103	32.3	3119	91.1	305	8.9	3424
Miscellaneous Manufacturing	337	65.8	156	30.5	493	96.3	19	3.7	512
Total Manufacturing	*25717*	*64.1*	*12867*	*32.1*	*38584*	*96.2*	*1512*	*3.8*	*40096*
Storage	920	55.7	554	33.5	1474	89.2	178	10.8	1652
Miscellaneous Occupancies	1529	67.3	641	28.3	2170	95.6	99	4.4	2269
Multiple Ocupancies	819	76.5	210	19.6	1029	96.1	42	3.9	1071
Total	33132	65.9	15204	30.2	48336	96.1	1974	3.9	50310

Table No. 2 Unsatisfactory Sprinkler Performance by Occupancy Groups

Occupancy Group	Water Shut Off	Partial Protection	Inadequate Water Supplies	System Frozen	Slow Operation	Defective Dry Pipe Valve	Faulty Building Construction	Obstruction to Distribution	Hazard of Occupancy	Exposure Fire	Inadequate Maintenance	Antiquated System	Miscellaneous and Unknown
Residential	6	2	..	1	..	..	4	1	1	..	..	2	..
Assembly	13	7	1	..	..	1	4	..	..	1	2	1	..
Institutional	1	..	..	..	..	..	1	..	1	..	..	1	..
Offices	2	..	1	..	..	1	..	..	1	..	1	1	..
Mercantile	44	2	1	..	2	1	20	5	4	1	5	1	..
Manufacturing													
Chemicals and Chemical Products	36	6	17	..	3	2	1	10	65	4	9	5	5
Fibre Products	6	..	3	..	..	1	..	4	2	..	2	1	..
Food Products	32	6	3	..	1	..	4	7	15	4	5	1	5
Glass Products	7	..	1	1	..	..	2	1	3	..	1	..	..
Leather Working	30	4	3	3	2	4	8	6	9	4	6	6	2
Metals and Metal Products	61	20	10	1	6	4	7	29	30	3	24	6	3
Mineral Products	11	3	..	..	..	..	1	..	..	..	1	1	..
Paper and Paper Products	45	3	17	2	2	..	6	28	12	2	17	4	2
Printing and Engraving	8	2	..	..	..	1	3	1	..	..	1	..	..
Rubber and Rubber Products	13	2	1	..	..	1	..	6	11	1	4	..	..
Tenant Mfg.	66	6	3	3	1	..	7	5	7	3	12	5	1
Textiles and Textile Products	113	9	21	1	10	3	12	32	20	1	43	9	11
Woodworking	90	31	43	5	13	9	21	14	47	5	13	10	4
Miscellaneous Manufacturing	10	..	3	..	1	..	2	..	..	1	1	1	..
Total Manufacturing	*529*	*92*	*125*	*16*	*39*	*25*	*74*	*142*	*221*	*28*	*139*	*49*	*33*
Storage	59	10	23	3	5	6	7	22	17	4	17	4	1
Miscellaneous Occupancies	15	1	2	4	..	2	11	3	4	..	..	..	..
Multiple Occupancies	58	7	2	2	..	2	2	2	15	2	5	..	2
Total	726	121	155	26	46	37	123	176	264	36	169	59	36

Table No. 3 — Detailed Analysis of Unsatisfactory Sprinkler Performance

	Residential	Assembly	Institutional	Offices	Mercantile	Manufacturing	Storage	Miscellaneous Occupancies	Multiple Occupancies	Total
Water to Sprinklers shut off										
Valve defective or leaky	..	..	..	..	..	2	..	..	..	2
Unsupervised valve closed for undetermined reason	..	5	..	..	5	121	20	5	11	167
Premature shut off	..	2	..	..	7	130	10	3	2	154
Alterations or repairs to system	1	3	..	1	9	119	11	1	13	158
To prevent freezing	1	1	1	1	16	90	9	5	23	147
Cold weather valve closed out of season	..	..	..	..	2	20	2	..	1	25
To abet arson	1	1	..	..	4	22	5	1	6	40
Fear of water damage	..	..	..	..	..	16	1	..	..	17
Miscellaneous other reasons	3	1	..	..	1	8	1	..	2	16
Partial protection										
Originated in unsprinklered area	2	7	..	..	2	92	10	1	7	121
Inadequate water supply										
Insufficient water or low water pressure from public supply	..	1	..	..	1	71	12	1	2	88
Insufficient water or low water pressure from private supply	..	..	..	..	..	9	2	..	..	11
Insufficient water for both sprinklers and hose streams	..	..	..	1	..	16	5	..	..	22
Gravity tank empty	..	..	..	..	..	16	3	..	..	19
Pump failure or pump not started	..	..	..	..	..	8	..	..	..	8
Mains broken	..	..	..	..	..	3	1	1	..	5
Miscellaneous reasons	..	..	..	..	..	2	..	..	..	2
System frozen										
Pipes or valves frozen	1	..	..	..	..	16	3	4	2	26
Slow operation										
Excessive heads on dry pipe valve	..	..	..	..	..	19	..	..	..	19
High temperature sprinklers	..	..	..	..	..	7	..	..	..	7
Failure of quick opening device	..	..	..	..	..	2	..	..	..	2
Heat actuating devices inadequate or inoperative	..	..	..	..	..	3	..	..	..	3
Miscellaneous reasons	..	..	..	..	2	8	5	..	..	15
Defective dry pipe valve										
Defective or improperly adjusted dry pipe valve	..	..	..	1	1	25	6	2	2	37
Faulty building construction										
Concealed horizontal or vertical spaces lacking protection	4	4	1	..	19	64	3	11	2	108
Floor or roof collapse	..	..	..	..	1	7	4	..	..	12
Miscellaneous deficiencies	..	..	..	..	..	3	..	..	..	3

(Continued on next page)

Table No. 3 (Continued)

	Residential	Assembly	Institutional	Offices	Mercantile	Manufacturing	Storage	Miscellaneous Occupancies	Multiple Occupancies	Total
Obstruction to distribution										
Fires under benches, etc.	..	..	..	..	..	75	3	1	1	80
High piling of stock	..	..	..	..	2	53	18	1	..	74
Partitions erected	1	..	..	..	3	10	1	1	1	17
Miscellaneous reasons	..	..	..	..	..	5	..	..	..	5
Hazard of occupancy										
Hazard too severe for sprinkler equipment as installed	..	..	..	..	2	125	7	2	7	143
Explosion damaged system	1	..	..	1	1	82	10	2	8	105
Water overflowed containers of flammable liquids	..	..	1	..	1	10	..	..	..	12
Miscellaneous reasons	..	..	..	..	..	4	..	..	..	4
Exposure fire										
Exposure fire overpowered sprinkler system in exposed building	..	1	..	..	1	28	4	..	2	36
Inadequate maintenance										
Plugged sprinklers	..	1	..	..	1	21	..	..	..	23
Sprinklers dirty, corroded or coated	..	..	..	..	1	30	2	..	2	35
Obstructed piping	..	1	..	..	3	85	15	..	3	107
Miscellaneous reasons	..	..	..	1	..	3	..	..	..	4
Antiquated system										
Pipe sizes, sprinkler spacing sub-standard or old-standard	2	1	..	..	1	46	4	..	..	54
Valves sub-standard or old-standard	..	..	..	..	..	1	..	..	..	1
Sprinklers sub-standard or old-standard	..	..	1	1	..	2	..	..	..	4
Miscellaneous and unknown										
Causes of unsatisfactory sprinkler performance unknown or cannot be otherwise classified	..	..	..	..	..	33	1	..	2	36
Total	17	29	4	7	86	1512	178	42	99	1974

Gas Explosions

An NFPA Staff Study

Explosions involving fuel gas in central piping distribution systems and in consumer properties and gas works served by or supplying such systems are briefly reviewed in this article. The information presented is based on a study of material contained in the NFPA files over the twenty-year period 1931-1950. Only a representative group of such explosions are reviewed, but in selecting the cases an effort has been made to indicate the relative hazards of such systems and to include a variety of occupancy types which reflect the wide scope of the problems involved. The cases summarized here involved a total of 554 deaths.

It should be noted that this record does *not* include liquefied petroleum gas systems utilizing individual property gas supplies or liquefied petroleum gas bulk plants not serving customers directly through underground pipe lines. Gas explosions involving other than "illuminating gas" are also *excluded*. Tank trucks, tank vessels and railroad tank cars have *not* been included.

The principal conclusion that should be drawn from these case histories is the ever present need for vigilance in the proper installation, maintenance, repair and operation of gas piping and equipments. The NFPA has had for many years a Standard for the Installation, Maintenance and Use of Piping, Appliances and Fittings for City Gas (NFPA No. 54, National Fire Codes, Volume I).

In order of their frequency, this review of gas explosions is divided into the following groups:

(1)	Building service line failures	26 cases
(2)	Street main failures	15 cases
(3)	Industrial failures	13 cases
(4)	Appliance failures	4 cases
(5)	Unexplained gas explosions	9 cases
	Total	67 cases

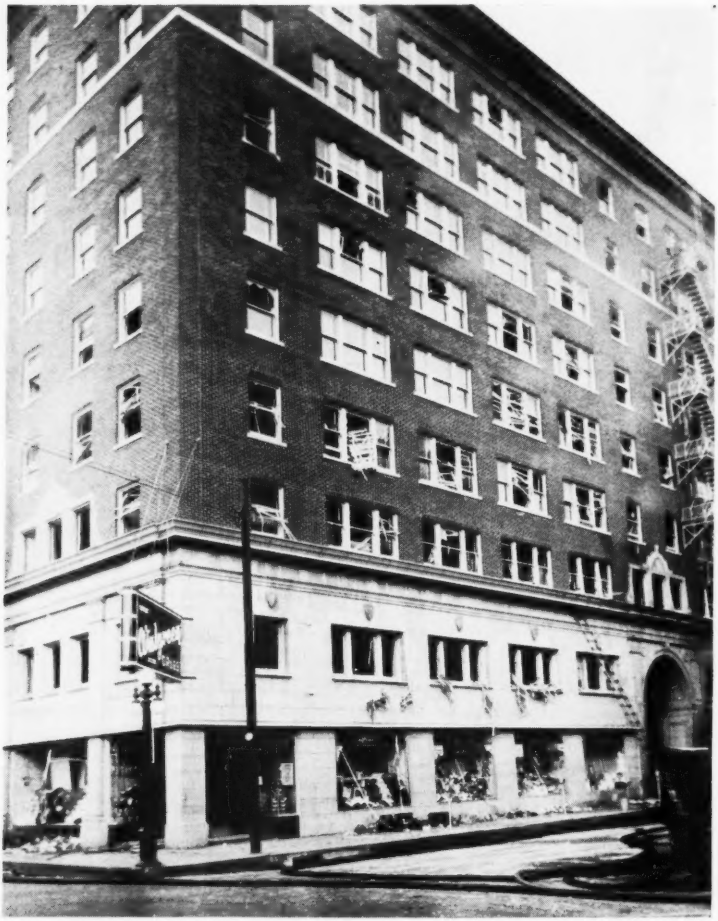
Building Service Line Failures

Apartment House, Wellesley, Mass., Dec. 21, 1931

One person was killed when a gas explosion virtually destroyed a two-story brick veneer, four-family apartment building. Fortunately, the building itself was unoccupied when the blast occurred. Only two persons were in their quarters just prior to the accident. They detected the odor of escaping gas, notified the gas company and left the building. The fatality occurred when they were returning to see if the condition had been corrected. The blast came as they were underneath a portico on the outside of the structure and the falling debris fatally injured a woman and seriously injured her husband. Gas had seeped into the basement from a leak in the building service line just outside the foundation and was ignited from an unknown source. The gas company accepted liability and paid the claims. The building loss was estimated at $35,000.

Stores and Apartments, Highland Park, Mich., Apr. 25, 1932

Coal, being laid-in through a basement window, smashed against a gas pipe joint and snapped it off, causing release of the gas into the



The Liberty Building, Waco, Texas, after the gas explosion and ensuing fire of October 4, 1936. Heavy damage occurred on the four lower floors, and several adjoining buildings were extensively damaged.

building which housed a plumbing shop, other stores and apartments. The building was heated by a coal furnace. The coal men quickly left, warned occupants and called both the fire department and gas company. Just as the firemen were putting on gas masks preparatory to entering the basement, the explosion occurred. Two persons were killed, twenty-three injured. The ensuing fire completed destruction of four stores and a flat. Buildings in an area of several blocks were damaged. The loss to the building of origin and exposures totaled about $30,000.

Church, Cloverdale, Ala., Nov. 29, 1932

Gas from an open gas cock in the tunnel of the First Methodist Church Sunday School Annex was ignited by an electrical inspector who went into the tunnel to inspect wiring using a match. The resultant blast wrecked the 90% completed annex and the loss was considered

almost total, with windows shattered in the balance of the church and surrounding residences. The electrician was instantly killed and an assistant seriously injured, but 25 others in the building suffered only from shock. The tunnel was reinforced concrete construction, built to house steam, electric and gas lines.

Town Hall, Seminole, Okla., Dec. 29, 1934

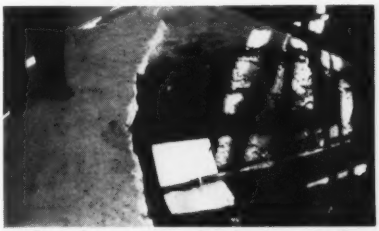
A gas explosion in the municipal building at Seminole killed three persons and critically injured two others. The gas accumulated under the floors of a gymnasium and in the walls. What set off the blast was not determined. The force was sufficient to almost completely demolish one entire section of the structure. The rest of the building had to be razed. The loss was estimated at the time at $35,000, but this apparently did not include losses to the library and records stored in the building.

Dwelling, Los Angeles, Calif., Oct. 30, 1935

Fire Department officials believe that a gas leak in a line between the meter and the street set the stage for an explosion which demolished a one-story stucco dwelling on West 88th St. The owner was standing just inside a screen porch door and when he lit a cigarette, the explosion occurred. His burns proved fatal. The explosion forced out the walls in practically every room in the dwelling, collapsing the roof. A flash fire extended from the back porch (where it originated) through the kitchen and into a bedroom. A neighbor was walking in front of the dwelling just prior to the blast and smelled gas. She was talking to the owner when the explosion took place. The gas company investigation reportedly found no leaks in the gas service lines despite the fact that firemen noted a strong odor quite some time after the meter had been closed.

Office Building, Waco, Texas, Oct. 4, 1936

A terrific explosion, followed by fire, caused $280,000 direct loss to three downtown buildings in Waco. It was fortunate that the blast occurred at 5:20 A.M. on a Sunday morning, when the office buildings and stores were largely unoccupied. The only known occupant, a janitor, died from injuries received. The main building involved was a modern, reinforced concrete, nine-story structure. Severe blast damage affected the first four floors and basement. Determination of the exact source of the natural gas which caused the explosion was made difficult by the damage in the area of origin. It is reported by a reliable investigator that the gas probably originated from a two-inch building service line which entered the basement boiler room through a pipe tunnel (3 ft. wide, 5 ft. high) at a point where the tunnel joined the street supply. It is presumed that ignition resulted when the janitor operated a light switch at the boiler room entrance.



Rusted gas pipe under the concrete floor was responsible for the explosion at Whitehurst Hall, Stillwater, Oklahoma, November 13, 1936. This pipe was six feet from a power tunnel.

College Building, Stillwater, Okla., Nov. 13, 1936

An explosion caused by the ignition of natural gas severely damaged Whitehurst Hall at the Oklahoma A. & M. College on this Friday the thirteenth. Five persons were injured, one seriously. Investigation disclosed that gas pipes, concealed under a concrete floor, had corroded and escaping gas had entered a power tunnel. Repair of an obstructed sewer drain was under way and the blast occurred just after an electric light bulb was lowered into the tunnel. A wire lamp guard had been removed to accommodate a 200-watt lamp and it is assumed that the lamp was broken as it was lowered into the concrete tunnel.

School, London, Tex., March 18, 1937

A gas explosion at the London Consolidated High School at 3:15 P.M. on March 18, 1937, caused one of the major disasters of the century, resulting in the death of 294 school children and teachers. The entire front section of the school (254 ft. by 58 ft.) was demolished and wings at both ends of the building and a center auditorium had to be razed after the supporting wreckage was removed. (See photo next page.)

The disaster resulted from ignition of an explosive natural gas-air mixture that accumu-

International

After the explosion which took 294 lives at London, Texas on March 18, 1937. Only small portions of the school were left standing. This picture shows the oil field workers engaged in removing the wreckage to uncover the corpses of the victims.

lated in an inadequately ventilated space beneath the first floor (concrete) of the main school building.* This space had a volume of 64,000 cubic feet. Gas was present in this space because of leakage from gas lines and fittings suspended beneath the floors, with virtually no method of detecting the gas or removing it by natural or forced ventilation. The manipulation of an electric switch on a panel in a manual training room ignited the gas. (For further details see NFPA QUARTERLY, April 1937, page 299.)

Multiple Occupancy Mercantile, Bristol, Va., Dec. 16, 1937

At 2:20 A.M. a taxi driver heard an explosion which blew a plate glass window from a restaurant which had closed about an hour earlier. Fire immediately ensued and before final control was established the four-story mercantile building was destroyed and fire had communicated to other exposed structures, aided by stocks of fireworks. The gas apparently leaked from pipes serving the restaurant range or from a gas fired stove and was ignited by a coal range or other open flames. The loss was estimated at $160,000.

A householder tried to turn off the gas himself in Cedar Rapids on March 1, 1939. This was the result.

Dwelling, Cedar Rapids, Iowa, Mar. 1, 1939

When a householder attempted to shut off the gas supply in the basement, a high pressure building service pipe line failed. An explosion resulted when the gas was ignited by a coal fire furnace. The lack of a curb cut-off allowed the gas to burn for 1½ hours before the service line could be dug up and the flow stopped. The domestic service line is said to have carried approximately 20 pounds per square inch pressure and, following the failure, the volume of gas released was accordingly great. The fire reduced the dwelling to a charred ruin (see photo).

Grocery Store, Atlanta, Tex., Apr. 15, 1939

Two of seven persons died from injuries received when a gas explosion destroyed the one-story Safeway Grocery Store and the adjoining Mays Storage Building in Atlanta. Investigation disclosed that the blast occurred within the Safeway building, below the double, one-inch wood floor. This space was a "dead" air foundation space, two feet deep, without ventilation. Gas leakage had been detected before at this location and an old distribution main, plugged with a wooden plug, was one suspected source, since one consumer (not the owners of either of the properties affected in this explosion) still secured his gas from this line.

School, Barberton, Ohio, May 31, 1939

During construction of a near-by sewer, a gas line was broken at a coupling 5 ft. 6 in. from the foundation of a school building in Barberton. Fifty children were injured, four seriously, when a blast almost totally wrecked the frame building being used temporarily as a schoolhouse. Gas odor had been detected within the school prior to the accident and the meter had been turned off, but the gas company was not notified. Readings of the gas consumption showed that the amount the school had consumed was not sufficient to cause the explosion.

Metal Worker, Toledo, Ohio, July 4, 1939

The Doehler Die and Casting Company plant was almost totally destroyed by a gas explosion caused by the failure of maintenance men to cap the end of a three-inch gas line before turning on the gas. They inspected the riser to the line but not the end. (The line hung from supports two feet from the ceiling for the length of the building.) The blast caused injuries to six workmen, broke windows within a quarter-mile area, and caused an estimated $40,000 loss. Larger casualties would undoubtedly have occurred if the explosion had happened during normal working hours instead of at 4:24 A.M.

*The gas used was "residue" or "wet" gas from a gasoline extraction plant and not commercial gas, but investigators concluded that the type of gas was not significant. The school superintendent admitted tapping the source without the permission of the operating gasoline companies.

Acme

The Doehler Die and Casting Company plant at Toledo, Ohio, after a gas explosion on July 4, 1939. Two maintenance men failed to cap the end of a three-inch gas line before turning on the gas. They inspected the risers to the three-inch line but not the end of the line. The blast caused injuries to six workmen and broke windows of buildings within a quarter mile area.

Acme

This former dwelling in Barberton, Ohio, was in use as a temporary public school housing 101 students when wrecked by a gas explosion on May 31, 1939.

School, Howe, Tex., Oct. 31, 1939

This was another case of leaking gas from a ruptured pipe line, supplying inside gas heating stoves, accumulating in a two-foot under-floor space lacking adequate ventilation. Fortunately, unlike the London, Texas, disaster of 1937 (see preceding pages), no deaths resulted, although 390 children were in session. The ignition and main blast force was in partially segregated area in one corner of the school, where only 25 students were directly exposed.

The leak in the pipe is attributed to movement of the ground following a long dry summer. Fissures in the ground had been formed and permitted the gas to flow under the foundation from the exterior piping and be ignited by a stove. Teachers, who had previously detected the odor of leaking gas the night before, did not investigate.

Multiple Occupancy Mercantile, Toppenish, Wash., Nov. 28, 1940

Eight persons died when an explosion demolished a multiple occupancy mercantile and storage building in mid-morning. The force of the blast flattened the two-story, 250 ft. long building, and those killed were crushed or trapped in the debris. Fire followed the explosion and those victims who could not be reached immediately were badly burned. Fourteen others received injuries. Evidence indicated that the gas service line to the building had been struck by a road grader working in an alley beside the building. It is believed that the break occurred just inside the foundation wall and the gas accumulated in this space and might have been ignited by a coal burning stove in the basement.

Stores and Apartments, Cincinnati, Ohio, Dec. 17, 1940

Seven children and six adults were killed by a gas explosion which destroyed a multiple occupancy mercantile and apartment building at 3:30 in the morning. Investigators reported that the destructive blast was typical of a gas explosion as the energy was distributed uniformly over all enclosing surfaces, resulting in a generalized displacement or buckling of floors and walls, but with little localized destruction. The general demolition made a shambles of the brick and wood building, burying many of the victims (see photo on following page). Forty-three other buildings in the area also suffered damage. Evidence as to the exact source could not be estab-

Illegal tapping of a gas main in a multiple occupancy store and an apartment building was responsible for this explosion at Cincinnati, Ohio, December 17, 1940, fatal to 13.

lished, as mechanical diggers had to be used to recover the bodies of victims, and this eliminated opportunities to probe carefully the remains. Testimony and analysis of the circumstances made probable the following explanation: a firm handling gas hot water heaters illegally tapped a gas line to operate the unit in a show window. While the remains of the work indicated a well done job, the gas pipe to which the connection was made was very old, and it is possible that some portion of the pipe was broken by the additional strain or vibration.

Laboratory, Tooele, Utah, May 9, 1942

A laboratory, warehouse and machine shop of the International Smelting and Refining Co. were destroyed by fire that followed a gas explosion in the laboratory at 1:00 A.M. A leak at the natural gas meter in the room was discovered promptly by the chemist on duty, but before help could be obtained to stop the flow, the explosion occurred. An open flame furnace was the probable igniting source.

Office Building, Coleman, Tex., Sept. 21, 1942

This explosion, which killed two and injured 19, wrecked the administration building at the Coleman Flying School. No fire resulted. The local Fire Chief reported to the NFPA that "it was an explosion caused by accumulation of natural gas under the floor due to faulty construction or work." A "jack-of-all-trades" was looking for the leak with a lighted match when the blast occurred.

Multiple Occupancy, Mercantile, Vandalia, Mo., Jan. 15, 1944

The Vandalia Fire Dept. responded without an alarm; the force of this explosion "shook" the town and response to the newspaper plant and furniture store was automatic. The chief reports that a leak in the gas main under the two-story brick, wood-joist building was responsible for the blast and the entire structure was a "furnace within five minutes." Cables in the telephone exchange in the next building were disrupted.

Apartments, New Orleans, La., Feb. 19, 1946

Seven persons were killed and thirty-eight injured when a natural gas explosion blew out the

lower floor walls of a three-story brick negro housing project. The cause has been laid to a leakage of gas caused by the corrosion of an underground pipe. A local ordinance requiring that these pipes be encased in cement (because of peculiar soil conditions) was partially complied with, but a short length was not so protected. Gas filled an open area under the building and entered one of the ground floor apartments through a pipe hole. When one of the tenants started to prepare breakfast at 6:50 A.M., the blast occurred. Cement columns held the building upright, but the falling walls and concrete flooring crushed seven of the occupants. Only sporadic fires in combustible furniture followed the explosion. Loss: $40,000.

Hotel, Dallas, Tex., June 21, 1946

A severe explosion in the basement of the 18-story Baker Hotel resulted in death to 10 persons and injury to more than 30 others. Remodeling work was being completed in the basement at 11:13 A.M. when the accident occurred. Two men were in a narrow concealed space above the commissary in which was located water, soil, ammonia and natural gas piping. Just prior to the explosion, a workman was plugging in an electric fan to dissipate heat and natural gas odors noted in the area. It is logically reasoned that this was the source of ignition and that natural gas rather than ammonia, sewer or other gases provided the destructive force. The blast caused extensive damage to the basement, the kitchen above, refrigerator and storerooms. Food supplies were rendered unfit for consumption, and wine and liquor stocks were severely damaged. The physical loss is estimated at $400,000.

Restaurant, Onset, Mass., July 18, 1946

A plumber who was called to repair a gas leak accidentally broke the high pressure line near the meter. This released large quantities of gas in Christy's Spa in the center of the business district. A resultant explosion shattered four frame buildings, killed nine persons and injured scores of others. The gas, butane, was supplied from underground mains by the Buzzards Bay Gas Company. The gas company was called for assistance by the plumber at 12:35. The Onset Fire Department had roped off the area between 12:35 and 1:00 P.M., when the odorized gas fumes gave a danger warning. The utility company was criticized in the inquest report as having been very slow in responding to the emergency call, but had done so approximately ten minutes before the explosion occurred (1:00 P.M.). The ignition source was suspected as an electric motor. The loss to property was estimated at approximately $150,000.

Pottery Plant, Vernon, Calif., Dec. 27, 1947

A 245 ft. by 380 ft. frame and iron-clad-on-frame, one-story chinaware factory was destroyed by fire which originated as an explosion at 7:20 P.M. A three-inch gas line came into the center of the plant building underground and then extended through the plant overhead. Apparently the line leaked at a point near an over-

Acme

Complete collapse followed a gas explosion in this dwelling in Aurora, Indiana, April 20, 1948. Fatally injured was a 79-year-old woman. At the time of the blast a flood disrupted normal communications in the town.

Columbus Dispatch

West front of building, showing the marble exterior facing in two lower stories shattered by force of explosion at Columbus, Ohio, April 14, 1932.

head heater, as evidence points to this origin. A watchman had just completed his rounds when the blast occurred and the whole structure seemed to burst into flame. The loss to building and contents was estimated at $715,000.

Dwelling, Aurora, Ind., Apr. 20, 1948

"Evidently gas escaped into the basement and was ignited by the electric heater, which was badly battered. The home was completely blown apart(see photo, previous page). Everything in the home destroyed, and when I arrived, possibly ten minutes after the alarm—it took that long to cross the flood water—the entire house was in the basement afire."—Fire Department report. One person was killed.

Apartment, New York, N. Y., May 5, 1948

Piano movers, attempting to bring a piano up a narrow stairway, accidentally ripped off a gas pipe connection at the cellar wall. Realizing the danger, the movers gave an immediate alarm to the four families in the structure. Employees of the utility company happened to be in the vicinity and responded immediately, but before they could reach the curb cut-off an explosion reduced the building to rubble. One of the flying bricks hit a member of the moving crew in the head and killed him instantly. Six others, including the gas company crew, were injured.

Laundry, Middletown, Ohio, Mar. 24, 1949

An explosion of natural gas in the basement of a laundry was followed by a fire that heavily damaged a two-story brick mercantile building housing the laundry, a candy store, a shoe shine parlor and apartments. A special investigating committee believed that the gas leak originated in the basement of the candy store and was ignited in the basement of the laundry when a workman operated a cigarette lighter. No lives were lost but the workman received second degree burns on the face and hands.

Street Main Failures

Stores, Beloit, Wis., Dec. 5, 1930

Four stores were destroyed and three others damaged by a gas explosion and the resulting fire. Windows and store fronts in a large part of the downtown business section were broken and damaged. The explosion occurred at 5:55 A.M., when practically no one was on the streets and the stores were empty. A defective valve at the bottom of a manhole was alleged to have caused the leak. Considerable litigation developed over whether a standard fire insurance policy covered explosion damages. Final settlement found the utility company paying, in one case, $75,000, while the insurance carrier paid $25,000 of the $100,000 claim.

Office Building, Columbus, Ohio, Apr. 14, 1932

Seven men were killed outright, three died subsequently and 53 others were more or less seriously injured by an explosion in midafternoon in a new state office building. The casualties involved workmen engaged in completing the interior of the 12-story fire-resistive building.

The center of the explosion was in the subbasement. The reinforced concrete basement floor overhead was entirely blown off, as was the central portion of the first floor embracing an area about 70 ft. x 160 ft. In this area the concrete floors were raised clear of the supporting steel girders and then fell back into the basement. The force of the explosion traveled up the elevator shaft, blowing out the partition walls on both sides on every story.

Suit was brought against the natural gas distributing company on the grounds that a 16-inch street main, improperly installed, developed a leak and caused gas to form pockets in the building basement. Suits were settled out of court for approximately $500,000.

This dwelling was reduced to shambles by a gas explosion in Newton, Mass., on October 29, 1937. Gas from a leaking street main seeped into the building through an inlet pipe.

Dwelling, Newton, Mass., Oct. 29, 1937

Twenty-two persons were injured by an explosion of gas that had accumulated during the night in a 2-story wooden dwelling. A match struck by an early riser is believed to have been the igniting source. The fire chief reported that gas leaking from a street main seeped along the inlet pipe and into the building. One of the tenants had reported the odor of gas several weeks before the explosion to the gas company, but the latter was not able to detect the origin of the leak during the ensuing time.

Dwellings, Merion, Pa., Nov. 30, 1937

Two gas explosions occurring within three minutes of each other in widely separated dwellings practically demolished the two buildings and caused several personal injuries. A gas company employee failed to regulate properly a valve controlling pressure in the mains, permitting excessive pressure to exist in the mains. Gas apparently leaked into the building from gas meters disrupted by the excessive pressure.

Office Building, Niagara Falls, N. Y., Jan. 21, 1939

Simultaneous explosions in a 5½-story office building and a department store across the street were blamed on leakage of gas from old gas mains in the vicinity (installed in 1860). The odor of gas was so serious that one section of the property (a grill room) was evacuated just prior to the blast. The offices and department store were fortunately closed for the day when the explosion occurred (7:25 P.M.). Fire ensued in one of the two structures. Damage was estimated at $60,000.

Warehouse, Roulette, Pa., Dec. 9, 1939

A violent explosion at 6:45 A.M. severely injured two employees and partly removed the roof of this 1-story wood frame, metal clad machinery warehouse at a gas compressor station. The ensuing fire completed destruction of the 5,280 sq. ft. building. A 3-inch natural gas pipe, about 3 feet beneath one corner of the structure, developed a leak during the night, allowing gas to seep into the building without employees being aware of it. The explosion occurred when one of the men lighted a match.

Feather Product Manufacturing, Detroit, Mich., May 11, 1944

Explosion of natural gas leaking from a broken pipe killed three persons, injured eight and shattered the 2-story brick, wood-joisted feather products plant. A 1½-inch "drip stock" pipe for a drip pot installation on a 6-inch street main was ruptured some time prior to the explosion when concrete was being broken up at street level. The gas company was found negligent by the coroner's jury for not repairing the leak, which had been called to the company's attention by several witnesses. Ironically, there was no gas service into involved buildings.

Acme

On January 29, 1945, in Hammond, Indiana, an eight-inch street main leaked and gas, collecting in the basement of a restaurant, exploded killing three persons and injuring seventeen others. The terrific force of the blast is evident from the building destruction shown in the picture.

Restaurant, Hammond, Ind., Jan. 29, 1945

An explosion in a bar in the basement of the 1- and 2-story brick, wood-joisted restaurant killed three persons and injured seventeen others. The explosion was due to a leak in an 8-inch gas main, operated at 150 lbs. pressure. The leak occurred some 350 ft. from the restaurant, and gas apparently followed the course of least resistance into the basement of the structure, entering through recessed casement windows and through small fissures in the 12-inch concrete foundation wall. The room in which the explosion occurred had a volume of 11,424 cubic feet. The construction of the basement consisted of a 12-inch concrete foundation wall, 5-inch reinforced concrete stub supported on 12 x 12 inch reinforced columns. The shock of the explosion split the foundation wall and raised the entire structure in a vertical manner. It is believed that the resistance to escape offered by heavy concrete pavement of the boulevard under which the high pressure industrial gas main ran caused the gas to seek an outlet through the basement of the building.

Glass Products, Columbus, Ohio, Nov. 12, 1945

A terrific explosion completely demolished a 2-story brick, plank and timber building occupied for the production of art glass, including church windows. Four men were injured, one of them being seriously burned. The men had just reported for work and when one of them pulled a string on a pendant light in the basement, an explosion occurred. Subsequent examination disclosed a broken gas main in front of the building. This main was 18 to 20 inches below the surface of the street on which a two-ton maul had been dropped to break up pavement during street repair work. It is believed that escaping gas finally worked along a service pipe into the building.

Bill Markey

A broken street main reduced this art glass manufacturing plant to ruins on November 12, 1945.

Auto Showroom, Pittsburgh, Pa., June 9, 1948

"My son lit a match to light a cigarette. The next thing I knew I was out on the street" was the description given by the owner of an auto-

mobile agency of an explosion that wrecked his showroom, damaged 15 other buildings in the congested business district and injured 16 persons. Natural gas had seeped into the building from a leak in a street main. The odor of gas had been noticed during the morning and a gas company crew were at work in front of the building when the blast occurred. Property damage totaled $80,000.

Office Building, Portland, Ore., Nov. 29, 1948

The only occupant of a two-story wooden building occupied as an office by the Commission of Docks was severely injured and the building destroyed by a gas explosion. A two-story reinforced concrete vault located in the center of the structure was the only part to remain intact. Wreckage was blown for 200 to 300 yards in all directions. Extensive damage was inflicted on property over a two-block radius and gas fires sprang up within seconds from street expansion joints, sewer drains and manholes. Following extensive investigation it was concluded that the explosion was caused by ignition of a large volume of gas that had entered the building from a ruptured 22-inch high pressure gas main. The immediate ignition of gas escaping from the ground, in some instances more than 300 feet from the break, was strong evidence that the break had preceded the explosion. It was also discovered that several reports had been made of gas leaks in the neighborhood since May 1948, although no evidence could be found that repairs had been attempted.

Department Store, Winchester, Va., June 23, 1948

A 9:55 A.M. explosion in the Raylass Department store, which killed one person and injured 18, was due to an accumulation of gas in the basement which ignited when an employee struck a match. Employees and early morning shoppers were trapped in the debris which resulted from the blast, but very little fire was found. The service to the building was from a gas line in the street, and from information available to the NFPA it would appear that the street main was the source of the leak. Exactly how the gas entered the store basement is not explained.

Street Gas Main, Allentown, Pa., Dec. 2, 1949

At 12:20 A.M. an explosion, presumably of illuminating gas released from a leaky main, tore a crater 10 feet deep and 50 feet wide in a street intersection on the edge of the business district. Five minutes later a water main burst 60 feet away and tore out a hole 15 feet wide. Flames fed by four ruptured 6-inch gas mains raged out of control for two hours. Water flowing at the rate of 10,000 gallons per minute tore out chunks of earth and weakened foundations of several dwellings and a hotel. Damage to streets, replacement of old gas and water mains and building repairs approximates $250,000.

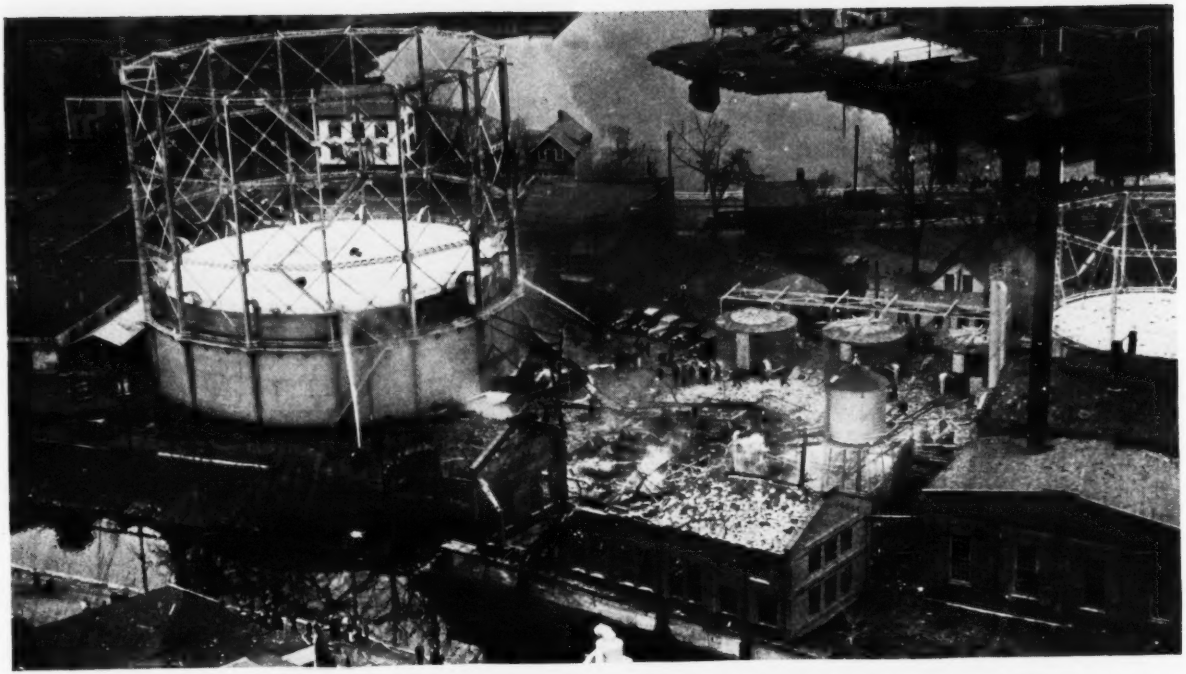
Swift & Co., Sioux City, Iowa, Dec. 14, 1949

Twenty-one employees at work in a six-story fire-resistive building were killed and ninety-one were injured by an explosion believed due to an accumulation of natural gas in the basement. The building (ground floor area 10,500 sq. ft.) was occupied partly by offices and partly by meat packing facilities. The force of the explosion ruptured the reinforced concrete hollow tile first floor, and caused it to fall into the basement; it buckled up the second and third floors, completely demolished a concrete loading dock, and blew off elevator doors on all floors and the penthouse roof to the elevator. The blast was so powerful that cracks developed in the 12½-inch thick reinforced concrete basement walls.

Although the source of the gas has not been definitely determined, it has been reported that a leak was found in a 16-inch cast iron natural gas line in the street. Since a 12-inch longitudinal split was discovered on the bottom of the gas line, where the pipe passed underneath two railroad spurs, it is surmised that this may have been the source of the gas. There was said to be no sleeve or casing to protect the gas line where it passed under the railroad tracks. The gas may have reached the basement through a pipe containing conduits and cables that passed over the gas pipe line and entered the basement where the explosion occurred. According to reports, this conduit pipe was not sealed when it entered the basement and was in poor physical condition. Property damage from this explosion was in the vicinity of $500,000.

Shoe Store, Willoughby, Ohio, Feb. 25, 1950

A gas explosion at 5:05 A.M. gave the alarm for fire which had involved a one-story shoe store and the basement of an adjoining Five-and-Ten Cent Store when apparatus arrived. A



International

Four men were killed and fifteen injured in an explosion in the compressor building of the Old Colony Gas Company, East Braintree, Mass., on April 9, 1940. Firemen are shown directing hose streams on the 750,000 cubic foot gas holder from which gas escaped and ignited following the blast.

Acme

This view of the Sioux City, Iowa, disaster on December 14, 1949, fatal to 21 employees of Swift and Company, shows the destructive force of a natural gas explosion in a fire-resistive building. Note disintegration of reinforced concrete flooring.

strong odor of gas noted in both structures on the preceding day had been reported to the gas company, but emergency repair crews reported they could find nothing wrong. Gas was *not* piped into either of the buildings involved. Investigation following the fire revealed a break in a buried two-inch main that passed within eight feet of the buildings and from which escaping gas seeped beneath the frozen earth crust into the structures.

A fire wall on which firemen relied to prevent spread to a drug store was of no help, since the wall did not extend through a blind attic. Loss is estimated at $270,000.

Industrial Failures

Gas Compressor Station, Union Township, Pa., Oct. 30, 1936

A gas explosion demolished a one-story gas compressor station and connecting office and inflicted fatal injuries on the two men in the building. The plant was located in the country several miles from any village, and at the time of the explosion was being used to pump gas from high pressure mains into near-by gas wells for winter storage purposes. Gas in the mains was under 550 psi pressure. The plant was shut down at 8:00 A.M. At 8:25 a 3-inch control shut-off valve in the discharge line from the gas compressor is thought to have broken, immediately filling the building with a gas-air mixture. Ignition may have been by a spark from wiring damaged by the ruptured valve, or by an open gas-fired heater in the adjoining and not cut-off office. The two men managed to reach a near-by creek to extinguish their burning clothing, but died later in the day from their injuries.

Gas Compressor Station, Braintree, Mass., Apr. 9, 1940

Four men were killed and fifteen other persons were injured when a gas explosion demolished a 1-story brick, steel frame compressor building. Three workmen had been sent into the building to make repairs on the steam end of one of the compressors. None of the machinery was in operation. Just what happened will probably never be known, but at 9:41 A.M. a devastating explosion took place which completely demolished the compressor building, as well as a second compressor building 35 feet away, badly damaged the walls and roof of the boiler house and generator building, 20 feet distant, and broke all windows on the exposed side of an office building and storehouse 200 feet away. The explosion also ruptured the 750,000 cubic foot three-lift gas holder 75 feet away. Blown out water seals in the gas holder were the probable source of escaping gas that continued to burn until the holder, which was three-quarters full, dropped to the empty position. Property damage totaled $275,000.

Soap Manufacturing, Oakland, Calif., May 7, 1942

Several times in the past the pilot light on the gas furnace at the Par Soap Company had gone out. The management was aware of this dangerous condition but it had not been rectified. In the absence of an automatic gas shut-off, it was necessary on each occasion to manually shut-off the gas supply and ventilate the furnace before relighting. On this particular night, however, the night man, on discovering the furnace out, neglected to take these necessary precautions before applying a torch. The furnace exploded and flames spread rapidly through the one-story combustible building. Damage was $180,000.

Gas Holder, Cleveland, Ohio, Oct. 20, 1944

Disaster struck and devastated part of Cleveland's industrial zone, taking the lives of 130 persons and causing $6,000,000 damage. The explosion and fire involved natural gas stored in insulated tanks at less than 5 psi pressure and at −250°F. Reports of eyewitnesses indicate that an insulated cylindrical tank of 150,000 cubic feet capacity failed, releasing its liquefied contents into the plant area. Ignition was almost immediate and flames soon caused an adjacent spherical tank of 100,000 cubic feet capacity to fail also. Burning liquefied natural gas flowed over the plant area and to adjacent properties. Even before fire department operations had commenced a large number of buildings in the neighborhood were burning fiercely. Gas accumulation in various sewers, underground electrical conduits, wellholes, basements and other depressions exploded repeatedly, blowing manhole covers into the air, raising pavements, rupturing water mains and sewers, and blowing out hundreds of windows. An area of 29 acres was completely consumed, including factory buildings, homes, automobiles and public utility equipment. Even hydrants and car rails were destroyed.

Gas Booster Station, Blackwell, Okla., Mar. 9, 1947

Three persons were killed and extensive property damage was incurred by an explosion and fire at the Cities Service plant when the header of a 26-in. natural gas main failed at 7:53 P.M. There were two distinct blasts; the first when gas from the broken header came in contact with heated machinery in the engine room and the second which involved unignited vapors which had permeated the area. The cooling tower, used to cool the gas as it came from the compressor, was destroyed by the heat and flame.

Scene of the Cleveland gas explosion and fire of October 20, 1944. An area of 29 acres was consumed by fire following the blast and 130 persons died in the disaster. The gas involved was liquefied natural gas in insulated tanks.

The engine room and compressor buildings were heavily damaged. The office was completely leveled. Flames ignited grass over a wide area. Terrific heat and fire prevented access to the area until the numerous gas valves around the plant and on the two 26-in. inlet lines could be shut off. Local fire fighters then used one hose line from the single hydrant available (on a 3-in. dead-end main, 1½ miles long) and booster tank supplies until they could reach a water basin near the cooling tower to secure suction supplies. An appreciation of the force of the explosion may be gained from the fact that a crater 15 ft. deep and 30 sq. ft. in area resulted and a 30 ft. section of the 26-in. pipe totally disintegrated. Loss is set by company officials at $1,000,000.

Three were killed when an explosion and fire ripped the natural gas booster plant at Blackwell, Oklahoma, on March 9, 1947.

Gas Holder, Buffalo, N. Y., Oct. 12, 1947

One man was killed and a truck garage, gas holder and solvent storage tank were destroyed in a series of explosions and fire. Gas is believed to have spilled from a broken water seal on a 25,000 cubic foot gas holder, drifted across a street and ignited in a garage. The 1-story brick masonry, wood-joisted garage of 25,000 sq. ft. area was practically destroyed and flame immediately flashed across the street to the gas holder and to an adjacent 40-ft. high solvent tank.

Gas Compressor Station, near Marion, Mich., Nov. 30, 1947

Following repairs on a 24-inch gas feeder pipe in the yard of the Michigan River Compressor Station, an explosion occurred which blew to bits an eight-foot long section of the main which was under 320 pounds pressure. (Normal operating pressures on the line varied with demand, but at times reached 625 psi.) Within 15 seconds the released gas caught fire, and the intense heat badly burned seven men, one fatally. A compressor station and several auxiliary structures were ignited. The gas could not be shut off for about 20 minutes, and the property loss to buildings, contents and equipment is estimated at $250,000. The evidence indicates that the main was defective, and an important lesson was that prior testing of the pipe might have prevented the loss. The value of locating control valves a safe distance from the operating area was also indicated.

Gas Pipeline, near Petersburg, Ind., Mar. 19, 1948

Two houses, two barns and several outbuildings in a 10- to 15-acre area were destroyed when a section of the "Big Inch" gas pipeline exploded and the escaped gas burned for more than two hours. The blast tore a hole in the ground 50 ft. by 20 ft., according to an Associated Press dispatch quoting the State Police. No further information is available.

Gas Pipeline, near Seymour, Ind., Nov. 19, 1948

A broken valve permitted gas to escape and become ignited near the Reddington Pumping Station of the "Big Inch" pipeline, five miles from Seymour. A wind of gale proportions blew the flames on the compressor station and it, four other structures and fourteen vehicles were destroyed. Thirty-one men on duty escaped serious injury, although three received severe burns. The blast occurred about 5:30 P.M., and it was two hours before the gas in the line was consumed. The nearest cut-off was 80 miles away. The question in the minds of many was whether the pressure on the 24-inch line was excessive for the system as designed. The operators have not responded to NFPA requests for additional data.

Acme

This power generating station at Tecumseh, Kansas, was the scene of a series of explosions on December 9, 1948. The initial blast may have been due to ignition of sewer gases, but two subsequent explosions undoubtedly resulted from ignition of natural gas from a ten-inch main.

Power Plant, Tecumseh, Kans., Dec. 9, 1948

Nine men were killed and sixteen injured by a series of explosions at the Kansas Power and Light Company steam turbo-electric generating station. The original boilers used natural gas supplemented by coal and oil, and a new boiler used pulverized coal, natural gas, or oil. At about 3:20 P.M. an explosion occurred in a six-foot air space beneath the basement of the boiler room. Before near-by workmen could escape, two more severe explosions occurred in the reinforced concrete, unprotected steel and brick plant. The exact cause of the initial blast is not known, but it is believed to have been due to ignition of an accumulation of sewer or natural gas in the unventilated six-foot air space. The subsequent explosions undoubtedly resulted from ignition of gas released from a 10-in. main on the basement ceiling. The property damage (see photo) is estimated at from $100,000 to $300,000.

Gas Booster Station, near Batesville, Ind., Jan. 19, 1949

Following a power failure, fire broke out in the Morris pumping station of the Texas Eastern Transmission Corporation's Big and Little Inch pipelines. The ensuing fire ignited gas in the 24-inch line and this fire continued until the gas was consumed in the pipe between Seymour, Indiana and Miamisburg, Ohio. Fed by the full pressure of the line, the flames roared almost 200 feet in the air. No further information is available.

Acme

The gas explosion in Chicago on January 28, 1949, broke windows and tore away interior partitions in this fire-resistive building 180 ft. from the source of the blast.

Gas Generator House, Chicago, Ill., Jan. 28, 1949

One gas company employee was killed and 13 injured in an explosion of water gas that demolished the blower house and severely damaged the adjoining water gas generating building. About 50 employees in a 14-story fire-resistive office and warehouse building 180 feet away were also injured when pressure waves blew in windows and damaged a number of partitions. The equipment involved in this explosion was stand-by apparatus undergoing its annual test. Investigation has traced this explosion to mechanical failure of the generator blast valve mechanism, which allowed gas to flow into the blower house and ignite. (See April 1949 QUARTERLY, page 295, for detailed report.)

Gas Pipeline, North Vernon, Ind., Mar. 4, 1949

An explosion of the "Little Inch" pipeline, the fourth pipeline explosion within a year in Indiana, spread flames to a farm home and outbuildings 150 feet from the line. The farmer's wife was seared by the flames as she fled from the house with her baby. Flames subsided when the flow of gas was stopped at near-by pumping stations.

Appliance Failures

Dwelling, Charleston, W. Va., Dec. 16, 1932

The Governor of West Virginia was burned when a gas explosion occurred in the basement of the Executive Mansion. Investigators determined that unburned gas escaped through the metal flue into the chimney while the furnace doors were closed and after the furnace pilot light went out. The gas had been turned on full by a thermostat. When the Governor opened the furnace door, a draft forced the gas through the flues to the gas flame under a hot water heater which utilized a connecting flue. There was no flash between the water heater and the furnace except through these metal flues, which were completely wrecked by the force of the explosion. Two furnace doors were blown five feet, but fortunately did not strike the Governor.

Department Store, Salt Lake City, Utah, Mar. 18, 1946

An explosion occurred in the Montgomery-Ward store at 10:48 A.M., when gas from a faulty furnace was ignited by the building en-

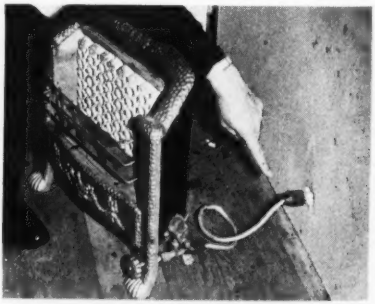
Beloit Daily News

A gas hot water heater originated this $400,000 fire in a refrigerator equipment manufacturing plant in Beloit, Wis., on September 7, 1949. A muffled explosion, a steady jet of flame and fire went through the roof within 90 seconds.

gineer attempting to light the furnace. The gas furnace was equipped with gas pilot lights, but no electrical safety pilot was provided. Investigation revealed that the gas pilot lights had become corroded and were partially clogged. Not realizing there was a heavy accumulation of gas in the room, he lit a match to light the pilot. The blast severely burned the engineer, damaged the heating system, ruptured the ceiling in locations adjacent to some sections of the ducts, and caused severe damage to the brick chimney through which the pressure vented. No general fire followed the explosion.

Dwelling, Tulsa, Okla., Oct. 12, 1946

A 2½-year-old child died of burns sustained following an explosion in her home due to the release of gas from a defective gas line extension (see photo). The little girl and her mother had left the house during the afternoon to go to the store. All doors and windows were closed, and two gas stoves and the kitchen range were turned off. When they returned home, the mother struck a match to light the kitchen range, and the explosion immediately occurred. A break in the flexible metal hose (shown in the photo) was cited by Fire Marshal George Askew as being responsible for the release of gas.



Failure of this hose caused escape of gas, its subsequent ignition and burns fatal to a 2½-year-old child at Tulsa, Oklahoma, Oct. 12, 1946.

Refrigerator Manufacturing, Beloit, Wis., Sept. 7, 1949

A night watchman in the Tekni-Craft Corp. plant in Beloit heard a muffled explosion and ran to the scene to find a gas hot water heater on the first floor afire. Flames were shooting into the air six to eight feet, and despite the fact that fire department equipment arrived within 90 seconds, the fire was through the roof of the second story. In a matter of minutes the entire north end of the building was involved (see photo). The loss to building and contents was estimated at $400,000.

Don Corvelli

Leaking gas was discovered by a match with this result to a home in Albuquerque, N. M., on August 11, 1938.

Unexplained Gas Explosions

Dwelling, Albuquerque, N. M., Aug. 11, 1938

The heavy structural damage to the dwelling shown in the photograph on this page was caused by a gas explosion. The exact source of the gas could not be determined, but the blast resulted when a friend of the family entered the house at 1:20 A.M. and lit a match to find, presumably, the light switch. The owners were on vacation and had been gone about two weeks. The victim was badly burned by the explosion.

Apartment Houses, Philadelphia, Pa., Feb. 11, 1941

Five persons were killed when four apartment buildings collapsed following two illuminating gas explosions. Eleven other buildings were partially damaged by the concussion and ensuing fire, and window lights and glass doors in twenty-nine other structures were shattered. Five firemen and eleven other citizens were injured. The only explanation available to the NFPA is that the first explosion originated about 5:00 A.M. at 1112 Greenwich St. This was followed by a second blast in a house across the street. Gas escaping from broken feed lines caused rapid spread of fire in the buildings initially involved. Fourteen hose streams were required to bring the blaze under control.

A mysterious blast at 5:00 A.M. in these Philadelphia apartment buildings on February 11, 1941, is attributed to illuminating gas. Five were killed, sixteen injured.

Bakery, New Orleans, La., May 20, 1945

Fire, starting from an explosion of natural gas in a baking oven on the first floor, caused the destruction of a brick, plank-and-timber, bakery building. Cause of the explosion was not determined. Flames fed by leaking gas spread rapidly up open stairways to the upper floors and were beyond the immediate control of the fire department hose streams. Loss was $60,000.

Gas Compressor Station, West Conshohocken, Pa., Jan. 22, 1947

An explosion from an unknown cause ruptured the gas mains feeding and distributing gas from the Compressor Building of the Philadelphia Electric Company plant in West Conshohocken. The escaping gas ignited and it was difficult to reach the control valve, which was located inside the compressor building, where the fire originated. Fire fighters could only cool the walls of the stone building and exposed storage tanks. Fog nozzles were used effectively to reach the interior valves to close down the gas source.

Restaurant, Chicago, Ill., Mar. 2, 1947

One of the most destructive gas explosions, as far as property damage is concerned, rocked a four-block area in the Chicago Loop area on this Sunday at noontime. Insurance reports indicate

Acme

Forty feet of gas pipe was ripped apart at this natural gas compressor station in Centralia, Mo., Dec. 8, 1949. Failure of a remote control valve handicapped control.

that the loss might reach $1,750,000, as damage was done to almost 100 buildings in the area. The explosion collapsed a three-story structure at 400-402 S. Wells Street which housed stores on the first floor. Four persons were killed and 30 hospitalized or given emergency first aid treatment. If the blast had occurred on a week day, perhaps hundreds would have been killed, as thousands worked in the vicinity during the normal work day. Fire developed in the building initially involved, requiring the services of multiple units of fire equipment. The bulk of the damage to exposed structures was to windows and witnesses described the sight as a "waterfall of glass." Chief Mullaney of the Chicago Fire Department advised the NFPA on March 31, 1950 (three years after the accident) that the exact cause still had not been determined.

Gas Compressor Station, Centralia, Mo., Dec. 8, 1949

A fire and explosion of unknown origin occurred almost simultaneously in a discharge line at a natural gas compressor station. Approximately 40 feet of pipe line was ripped apart, a small wooden warehouse was destroyed, and the compressor and pumping station, cooling towers, gas scrubbers and other equipment was damaged by the flying debris and intense heat from the fire. Failure of a remote control valve to operate prolonged the fire and contributed materially to the heavy damage.

Church, Beatrice, Neb., Mar. 1, 1950

An explosion of natural gas in the basement completely demolished a one-story church. Fortunately no one was injured. By coincidence all members of the choir were late for rehearsal. Had they been on time there would almost certainly have been several serious or fatal injuries. This particular explosion was a feature of *Life* magazine, issue of March 24. Investigation is continuing to determine the source of the gas. The fact that a valve on a supply line inside the building was found closed suggests that there may have been an unreported leak some time prior to the explosion.

Gas Regulator Station, near Springfield, Mo., March 7, 1950

A small fire in a gas regulator station, outside city limits, was detected about 2:20 A.M. by a passer-by. This chance observation permitted

giving warning to three occupants of a neighboring dwelling and filling station before an explosion occurred. The force of the blast destroyed the regulator station and the flames quickly engulfed the dwelling. The interruption of normal gas supplies created an emergency situation throughout the city, in hospitals, in industrial plants, in stores and in dwellings. An explosion occurred in a bakery when an employee attempted to light a gas-fired oven before it had been completely gas-freed.

Multiple Occupancy Mercantile, Statesboro, Ga., March 18, 1950

Two employees are expected to recover after fire department rescues were effected following an explosion in a two-story brick, ordinary joist mercantile building. The explosion wrecked the building of origin and one adjoining building. The ensuing fire completed destruction of a furniture store, a feed store, a barber shop and a pool room. Exposures suffered moderate explosion and fire damages. The blast resulted when an employee attempted to light a radiant space heater which was served by liquefied petroleum gas from an underground gas pipe. (The gas company serves 50 customers with gas from three 1,000-gallon underground tanks.) Gas odors had been noted in the furniture store for two days before the explosion, but no leaks could be found by the gas company employee who was called. Whether the explosion was the result of undetected leaks in the piping or gas escaping from a control valve accidentally left open on the space heater could not be determined. The loss is estimated at $300,000.

Statesboro, Ga., furniture and feed store is shown ablaze within five minutes after a gas explosion wrecked the structure on March 18, 1950, and caused about $300,000 damage. The gas was supplied by underground pipes from three 1,000-gallon liquefied petroleum gas tanks on a system which serviced 50 customers in the area.

Fire Record of Cities, 1949

The following tables summarize the fire experience for 1949 in cities with population over 20,000 in the United States and Canada. Of the 575 cities canvassed, 549 reported.

These statistics have been collected and published in the April QUARTERLIES since 1943 and represent a permanent reference for members who desire to determine fire experience trends within a particular city by comparing present with past experience. It is *not* intended that these tables be the basis of comparisons among different cities, as comparisons based on these statistics may be misleading. The principal discrepancy results from the wide variation among fire officials as to what constitutes a fire loss. Certain reports include only insured losses, others only uninsured. Whether or not property is insured, of course, has no bearing on the actual value of property destroyed. Variations in degree of industrialization, differences in topography, climate and age of cities also influence the fire record. In other words, fire losses reflect the composite results of many different factors in addition to fire department efficiency and therefore the practice of making comparisons among different cities based on these data is to be discouraged.

Fire departments of 498 United States cities and 47 Canadian cities of over 20,000 population have reported their estimates of fire loss, fire alarms, building fires, and false alarms for 1949 to the NFPA Department of Fire Record.

A total of 495 U. S. cities having more than 20,000 population reported a fire loss for the year 1949 of $170,676,145, amounting to an average loss per person of $3.11 for the 54,965,761 inhabitants of this group. This figure is ten per cent less than the $3.45 average loss for 1948.

Forty-seven Canadian cities having a total population of 4,543,894 reported a total loss of $19,079,369 for 1949. This was a per capita loss of $4.20, a nine per cent decrease from the $4.62 per capita loss in Canadian cities in 1948.

A total of 425 U. S. cities reported both loss data and the number of building fires. The average loss per building fire in these cities for 1949 was $674, compared with $731 in 1948. The average loss per building fire for 44 Canadian cities was $744 in 1949, compared with $807 in 1948.

The total number of building fires reported by 492 U. S. cities was 235,882, an average of 4.20 fires per 1000 population, as compared with 4.43 building fires per 1000 population in 1948, and 4.20 in 1947. Forty-seven Canadian cities reported 25,114 building fires in 1949. The number per 1000 population was 5.53 in 1949, as compared with 5.65 in 1948.

Automobile fires (including trucks) reported by 470 U. S. cities totaled 74,168, an average of 1.37 fires per 1000 population. Forty-six Canadian cities reported 2,822 automobile fires, an average of 0.62 per 1000 population.

Fire departments in 499 U. S. cities of more than 20,000 population answered 727,002 alarms in 1949. The number of alarms answered by the fire departments in 47 Canadian cities was 53,040.

In the United States, 479 cities of over 20,000 reported 53,546 false alarms in 1949. This was 7.7 per cent of the total calls answered. It will be noted that these are "malicious false alarms" and not just cases where smoke or steam, etc., was honestly mistaken for fire. Forty-four Canadian cities reported 6,112 malicious false alarms, or 11.7 per cent of their total calls.

The populations of many cities have changed since 1940. However, to keep the data comparable, we have used the 1940 U. S. census figures except in cases where the Census Bureau has issued recent official population estimates.

Fire departments have been very cooperative in furnishing fire loss figures. Most of the 26 nonreporting cities did not record their fire experience, and only Brookline, Mass., refused to release its 1949 record for publication. In a number of cases these are preliminary loss estimates and may be subject to upward revision when end-of-year fire losses are adjusted.

While there are occasional discrepancies in the manner in which certain cities report losses, our questionnaire calls for the total fire loss, both insured and uninsured, and this is the figure given unless otherwise indicated. Chimney and roof fires have been included in the number of building fires. A few cities do not give a complete record, but on the whole it is believed that these figures present a reliable indication of the relative trends in city fire losses in the United States and Canada.

1949 FIRE LOSSES, CITIES OF 20,000 POPULATION AND OVER

City	Population (Last Census)	Total Loss 1949	No. Alarms 1949	No. Bldg. Fires 1949	No. Auto Fires 1949	No. Malicious False Alarms 1949	Bldg. Fires Per 1000 Population
ALABAMA							
Anniston	25,523	90,615	420	150	38	15	5.9
Bessmer	22,826	27,925	179	80	19	2	3.5
Birmingham	267,583	1,491,881	3,347	978	...	298	3.7
Gadsden	36,975	140,630	748	245	65	32	6.6
Mobile	106,727	152,181	937	564	122	65	5.3
Montgomery	78,084	86,137	883	398	98	95	5.1
Phenix City	22,187	9,295	119	60	10	2	2.7
Tuscaloosa	27,493	70,608	312	129	46	23	4.7
ARIZONA							
Phoenix	65,414	302,690	962	374	152	60	5.7
Tucson	36,818	47,694	703	102	86	72	2.8
ARKANSAS							
Fort Smith	50,724	91,993	868	229	60	33	4.5
Hot Springs	27,150	126,556	325	130	60	17	4.8
Little Rock	98,302	1,126,324c	1,783	576	190	0	5.9
North Little Rock	39,552	94,135	836	186	76	13	4.7
Pine Bluff	34,630	164,214	552	239	75	6	6.9
CALIFORNIA							
Alameda	89,906	75,235c	733	207	54	84	2.3
Alhambra	50,671	75,657	357	31	52	37	0.6
Arcadia	21,556	25,048	169	26	25	...	1.2
Bakersfield	32,807	149,391	739	149	151	81	4.5
Belvedere Twp.	37,192	.....	...	...	...	...	...
Berkeley	103,315	152,369	1,516	430	125	49	4.2
Beverly Hills	28,217	110,912	402	119	56	28	4.2
Burbank	53,899	186,745	747	189	99	6	3.5
Compton	42,789	71,511	480	108	52	4	2.5
Coronado	25,382	42,157	145	29	10	14	1.2
Fresno	63,672	327,661	752	203	125	61	3.5
Glendale	96,495	190,640	940	240	119	49	2.5
Huntington Park	28,648	39,617	230	74	46	6	2.6
Inglewood	42,964	2,735,009	408	127	71	19	3.0
Long Beach	241,109	414,832	1,852	451	185	52	1.9
Los Angeles	1,805,687	3,104,902	23,845	6,238	2,701	1,567	3.5
Lynwood	20,650	5,645c	158	32	18	6	1.6
Oakland	400,935	1,277,306	4,384	1,356	389	608	3.4
Palo Alto	22,789	14,915	242	47	40	38	2.1
Pasadena	98,279	75,282	1,252	365	189	80	3.7
Pomona	23,539	28,715	605	101	63	9	4.3
Redondo Beach	21,288	12,404	344	119	33	14	5.6
Richmond	101,519	189,343	668	206	76	63	2.0
Riverside	43,939	160,694	521	118	59	13	2.7
Sacramento	119,984	216,513a	1,614	458	204	162	3.8
San Bernardino	56,193	347,971	765	140	101	46	2.5
San Diego	362,658	506,833	3,198	978	385	93	2.7
San Francisco	827,400	.....	12,342	3,758	633	1,511	4.5
San Jose	68,457	339,451	1,031	229	102	17	3.3
San Leandro	26,701	38,413	262	63	21	2	2.4
San Mateo	32,580	84,928b	498	68	66	7	2.1
Santa Ana	38,015	125,548	483	122	58	22	3.2
Santa Barbara	38,338	49,428	687	189	68	39	4.9
Santa Cruz	21,874	97,896	331	100	23	27	4.6
Santa Monica	67,473	184,513	925	279	108	52	4.1
South Gate	49,491	52,021	893	133	...	9	2.7

a. Estimated. b. Insured losses only. c. Building and contents loss only.

City	Population (Last Census)	Total Loss 1949	No. Alarms 1949	No. Bldg. Fires 1949	No. Auto Fires 1949	No. Malicious False Alarms 1949	Bldg. Fires Per 1000 Population
CALIFORNIA (Continued)							
Stockton	65,924	270,507	1,218	289	121	72	4.4
Vallejo	20,072	103,295	457	106	81	66	5.3
COLORADO							
Colorado Springs	36,789	24,325	545	91	8	23	2.5
Denver	322,412	1,500,000a	3,718	1,439	434	390	4.5
Pueblo	52,162	136,089	2,577	354	127	35	6.8
CONNECTICUT							
Ansonia	20,000	56,814	102	54	16	6	2.7
Bridgeport	147,121	490,725	1,408	533	...	55	3.6
Bristol	30,167	22,351	305	57	40	19	1.9
Danbury	22,339	171,477	330	198	20	12	8.9
East Hartford	28,000	35,906	387	93	72	16	3.3
Fairfield	21,135	71,200	619	80	41	5	3.8
Greenwich	35,509	53,847	761	160	65	1	4.5
Hamden	23,373	.....	...	...	...	...	...
Hartford	166,267	428,775	1,962	622	331	158	3.7
Manchester	23,799	15,127	180	18	23	6	0.8
Meriden	39,494	86,117	365	151	39	14	3.8
Middletown	26,495	175,387	155	65	51	4	2.5
New Britain	68,685	141,009	701	212	62	23	3.1
New Haven	160,605	413,512	2,443	760	209	161	4.7
New London	30,456	66,196	593	117	45	13	3.8
Norwalk	39,849	189,346	585	203	105	19	5.1
Norwich	23,652	108,958d	353	185	27	5	7.8
Stamford	47,938	261,479	894	154	100	64	3.2
Stratford	22,580	45,675	428	82	36	...	3.6
Torrington	26,988	23,577	248	75	25	11	2.8
Waterbury	99,314	181,974	1,322	402	86	69	4.1
West Hartford	33,776	72,273	404	132	44	11	3.9
West Haven Twp.	30,021	51,407	381	19	24	29	0.6
DELAWARE							
Wilmington	111,432	179,085	1,182	567	155	19	5.1
DISTRICT OF COLUMBIA							
Washington, D. C.	833,720	1,263,285	9,485	2,917	997	1,205	3.5
FLORIDA							
Daytona Beach	22,584	132,635	313	114	35	2	5.1
Jacksonville	173,065	496,972	2,618	593	198	107	3.4
Lakeland	22,068	35,075	518	111	43	...	5.0
Miami	172,172	937,018	3,762	526	197	217	3.1
Miami Beach	28,012	176,747	570	159	78	17	5.7
Orlando	50,939	35,820	503	16	37	35	0.3
Pensacola	37,449	82,443	500	114	54	27	3.0
St. Petersburg	60,812	74,386	1,768	223	82	11	3.7
Tampa	108,391	408,953	1,243	358	139	135	3.3
West Palm Beach	33,693	48,463	367	29	26	11	0.9
GEORGIA							
Athens	20,650	11,273	262	151	47	6	7.3
Atlanta	302,288	285,284	4,836	1,324	468	251	4.4
Augusta	65,919	214,908	941	427	197	58	6.5
Columbus	53,280	61,684	628	283	93	63	5.3

a. Estimated. d. Subject to change.

City	Population (Last Census)	Total Loss 1949	No. Alarms 1949	No. Bldg. Fires 1949	No. Auto Fires 1949	No. Malicious False Alarms 1949	Bldg. Fires Per 1000 Population
GEORGIA (Continued)							
La Grange	21,983	64,942	370	31	52	10	1.4
Macon	57,865	350,875	587	342	99	34	5.9
Rome	26,282	103,014	526	280	40	22	10.7
Savannah	95,996	.....	...	...	...	...	...
IDAHO							
Boise	26,130	204,920c	402	88	20	17	3.4
ILLINOIS							
Alton	31,255	177,245	439	238	79	4	7.6
Aurora	47,170	237,452	676	251	83	16	5.3
Belleville	28,405	278,219	440	98	67	1	3.5
Berwyn	48,451	27,931	521	95	32	6	1.9
Bloomington	32,868	70,515	450	140	63	39	4.3
Champaign	23,302	80,299	308	254	37	7	10.9
Chicago	3,396,808	8,180,000	42,814	11,258	4,799	4,656	3.3
Chicago Heights	22,461	52,756	188	101	20	18	4.5
Cicero	64,712	338,480	905	189	82	64	2.9
Danville	36,919	519,897	550	124	51	12	3.4
Decatur	59,305	181,812	627	350	114	10	5.9
East St. Louis	75,609	102,631	1,137	557	127	82	7.3
Elgin	38,333	163,168	338	77	61	10	2.0
Evanston	65,389	128,130	1,014	306	80	53	4.7
Freeport	22,366	252,070	329	116	5	20	5.2
Galesburg	28,876	39,885	362	182	61	2	6.3
Granite City	22,974	13,961	283	140	33	1	6.1
Joliet	42,365	403,797	831	288	50	28	6.8
Kankakee	22,241	47,655	410	90	20	13	4.1
Maywood	26,648	20,635	273	108	30	11	4.1
Moline	34,608	90,255	466	52	34	29	1.5
Oak Park	66,015	80,489	503	260	72	9	3.5
Peoria	105,087	438,957	1,387	665	197	109	6.3
Quincy	40,469	67,417	650	235	80	25	5.8
Rockford	84,637	165,629	1,130	477	181	15	5.6
Rock Island	42,775	942,534	647	332	105	36	7.8
Springfield	75,503	621,561	1,020	...	...	49	...
Waukegan	34,241	29,962	648	239	57	25	7.0
INDIANA							
Anderson	41,572	86,117	605	426	85	45	10.2
Bloomington	20,447	23,275	319	115	44	12	5.6
East Chicago	54,637	145,995	904	66	82	72	1.2
Elkhart	33,434	140,334	743	286	78	25	8.6
Evansville	97,062	136,961	1,529	688	243	115	7.1
Fort Wayne	118,410	195,000	1,870	851	238	162	7.2
Gary	111,719	103,025	1,431	1,127	...	188	10.2
Hammond	70,184	123,119	1,288	367	113	66	5.2
Indianapolis	386,972	607,621	4,458	2,071	683	374	5.4
Kokomo	33,795	88,765	477	287	86	32	8.5
Lafayette	28,798	108,111	425	228	82	18	8.0
Logansport	20,177	17,358	456	229	...	26	11.3
Marion	26,767	111,384	426	265	70	...	9.9
Michigan City	26,476	53,814	397	164	38	5	6.2
Mishawaka	28,298	18,578	436	169	57	47	6.0
Muncie	49,720	224,060	803	388	118	57	7.8
New Albany	25,414	223,601	378	258	41	18	10.2
Richmond	35,147	61,884	483	63	74	28	1.8
South Bend	101,268	249,981	1,479	576	180	199	5.7
Terre Haute	62,693	93,450	1,312	586	153	23	9.4

c. Building and contents loss only.

City	Population (Last Census)	Total Loss 1949	No. Alarms 1949	No. Bldg. Fires 1949	No. Auto Fires 1949	No. Malicious False Alarms 1949	Bldg. Fires Per 1000 Population
IOWA							
Burlington	25,832	168,768	558	173	60	27	6.7
Cedar Rapids	62,120	96,037	765	347	102	25	5.6
Clinton	26,270	105,438	408	354	52	2	13.5
Council Bluffs	41,439	27,113	632	211	74	28	5.1
Davenport	66,039	104,782	950	414	144	49	6.3
Des Moines	159,819	1,431,437	2,775	767	336	122	4.8
Dubuque	43,892	80,421	914	289	97	15	6.6
Fort Dodge	22,904	24,140	416	131	58	8	5.4
Mason City	27,080	24,574a	440	91	38	...	3.4
Ottumwa	31,570	428,478	735	159	124	...	5.0
Sioux City	82,364	194,273	1,230	445	146	43	5.4
Waterloo	51,743	326,819	952	332	115	110	6.4
KANSAS							
Hutchinson	30,013	69,482	590	151	84	36	5.0
Kansas City	121,458	185,861	2,106	1,072	204	70	8.8
Salina	21,073	51,428	454	141	90	6	6.7
Topeka	67,833	133,968	936	246	131	65	3.6
Wichita	114,966	146,974	1,908	466	221	60	4.1
KENTUCKY							
Ashland	29,537	.....	...	...	...	...	...
Covington	62,018	13,316a	625	208	82	21	3.4
Lexington	49,304	46,371	651	243	129	60	4.9
Louisville	319,077	615,243	3,405	1,838	527	156	5.7
Newport	30,631	7,251	326	246	51	19	8.0
Owensboro	30,245	60,959	526	225	62	19	7.5
Paducah	33,765	78,153	849	269	62	14	8.0
LOUISIANA							
Alexandria	27,066	120,835	342	154	65	36	5.7
Baton Rouge	34,719	147,476	1,084	637	142	72	4.3
Lake Charles	21,207	47,093	289	61	...	77	2.9
Monroe	28,309	239,561	784	192	80	24	6.8
New Orleans	494,537	641,210a	3,848	1,147	...	218	2.3
Shreveport	98,167	264,386	1,052	403	134	47	4.1
MAINE							
Bangor	29,822	571,343	524	339	62	40	11.5
Lewiston	38,598	160,954	799	63	50	3	1.6
Portland	73,643	77,604a	1,403	242	...	74	3.3
MARYLAND							
Baltimore	859,100	6,250,615	11,170	5,448	1,524	725	6.3
Cumberland	39,483	65,000	391	203	48	37	5.1
Hagerstown	32,491	80,299d	375	165	33	23	5.1
MASSACHUSETTS							
Arlington	40,013	52,212	863	...	...	38	...
Attleboro	22,071	3,908,530	580	109	41	13	4.9
Belmont	26,867	64,520	555	161	42	24	6.0
Beverly	25,537	99,029d	829	209	45	24	8.2
Boston	770,816	.....	16,339	4,004	1,157	...	5.2
Brockton	62,343	125,370	1,918	425	111	48	6.8
Brookline	56,940	.....	...	...	...	...	...
Cambridge	110,879	252,866	2,538	1,043	165	308	9.4
Chelsea	41,259	128,111	1,162	140	49	94	3.4
Chicopee	41,664	95,787	657	131	35	33	3.1
Everett	46,784	192,650	986	175	71	100	3.7
Fall River	115,428	80,290	1,296	393	122	41	3.4

a. Estimated. d. Subject to change.

City	Population (Last Census)	Total Loss 1949	No. Alarms 1949	No. Bldg. Fires 1949	No. Auto Fires 1949	No. Malicious False Alarms 1949	Bldg. Fires Per 1000 Population
MASSACHUSETTS (Continued)							
Fitchburg	41,824	213,060	823	252	65	19	6.0
Framingham	23,214	213,762b	783	201	...	14	8.6
Gardner	20,206	93,910	373	198	16	5	9.8
Gloucester	24,046	141,338	673	182	16	13	7.6
Haverhill	46,752	160,950	1,341	211	59	71	4.5
Holyoke	53,750	106,314	1,188	416	55	66	7.7
Lawrence	84,323	151,064a	1,476	284	147	70	3.4
Leominster	22,226	54,280	465	...	30	7	...
Lowell	101,389	305,037	1,801	374	197	53	3.7
Lynn	98,123	848,778d	2,405	784	160	183	8.0
Malden	58,010	201,559	1,280	115	60	54	2.0
Medford	63,083	255,054	1,335	207	126	73	3.3
Melrose	25,333	28,269	645	54	...	6	2.1
Methuen	21,880	85,897	596	127	32	10	5.8
New Bedford	110,341	128,979	1,038	392	84	44	3.6
Newton	69,873	135,610	1,849	135	76	79	1.9
North Adams	22,213	94,231	308	158	32	28	7.1
Northampton	24,794	45,623	372	163	35	5	6.6
Peabody	21,711	113,816	603	127	76	18	5.9
Pittsfield	49,684	122,633	753	223	56	22	4.5
Quincy	75,810	135,119	2,311	339	116	102	4.5
Revere	34,405	167,305	1,342	52	62	134	1.5
Salem	41,213	147,598	923	186	180	14	4.5
Somerville	102,177	.....	...	...	...	...	...
Springfield	149,554	392,875	2,699	562	187	250	3.8
Taunton	37,395	56,195	709	212	57	36	5.7
Waltham	40,020	182,158	1,083	149	58	153	3.7
Watertown	35,427	135,126	705	128	38	36	3.6
Weymouth	23,868	60,726	812	133	52	26	5.6
Worcester	193,694	733,552	4,737	2,073	280	430	10.7
MICHIGAN							
Ann Arbor	29,815	79,985	448	116	48	8	3.9
Battle Creek	43,453	129,811	937	221	114	80	5.1
Bay City	47,956	340,462	972	332	103	24	6.9
Dearborn	72,985	196,923	920	194	138	80	2.7
Detroit	1,654,972	6,732,945	17,170	7,101	2,333	1,773	4.3
Ferndale	27,392	30,723	363	137	51	19	5.0
Flint	151,543	575,522	2,077	1,069	198	...	7.1
Grand Rapids	164,292	393,645	1,536	685	125	128	4.2
Hamtramck	52,470	194,847	611	469	42	75	8.9
Highland Park	50,810	93,917	699	421	84	42	8.3
Jackson	49,656	127,540	691	235	92	44	4.7
Kalamazoo	54,097	158,319	756	381	118	45	7.0
Lansing	78,753	171,918	2,033	266	186	83	3.4
Muskegon	50,215	36,815a	532	229	56	25	4.6
Pontiac	73,752	242,183	1,029	342	90	93	4.6
Port Huron	32,759	182,030	553	216	61	26	6.6
Royal Oak	35,319	.....	...	...	...	...	...
Saginaw	82,794	84,295	1,208	380	118	76	4.6
Wyandotte	30,618	33,930	490	276	64	47	9.0
MINNESOTA							
Duluth	101,065	312,708	1,373	232	...	54	2.3
Minneapolis	492,370	2,268,496	5,258	1,072	544	289	2.2
Rochester	26,312	47,082a	43	128	42	78	4.9
St. Cloud	24,173	32,184	260	115	34	12	4.8
St. Paul	287,736	1,000,000a	3,961	820	480	202	2.9
Winona	22,490	57,015	334	173	46	14	7.7

a.Estimated. b. Insured loss. d. Subject to change.

City	Population (Last Census)	Total Loss 1949	No. Alarms 1949	No. Bldg. Fires 1949	No. Auto Fires 1949	No. Malicious False Alarms 1949	Bldg. Fires Per 1000 Population
MISSISSIPPI							
Greenville	20,892	32,021	322	182	28	4	9.1
Hattiesburg	21,026	172,812c	472	43	31	...	2.0
Jackson	62,107	304,765	978	383	124	...	6.2
Laurel	20,598	90,779a	233	123	26	2	6.0
Meridian	35,481	202,061	596	235	75	34	6.6
Vicksburg	24,460	15,200	406	27	42	18	1.1
MISSOURI							
Cape Giradeau	20,208	53,054	288	143	30	5	7.1
Hannibal	20,865	18,319d	338	202	75	8	9.7
Jefferson City	24,268	36,428	398	98	31	8	4.0
Joplin	37,144	26,420	975	312	166	22	8.4
Kansas City	399,178	1,466,515	5,839	1,753	717	242	4.4
St. Joseph	75,711	157,836	1,493	489	197	45	6.5
St. Louis	822,630	1,820,349	9,129	3,978	1,054	997	4.8
Sedalia	20,428	211,538	310	156	39	2	7.6
Springfield	61,238	258,010a	1,410	489	129	33	8.0
University City	33,023	28,140	455	201	43	3	6.1
MONTANA							
Billings	23,024	385,302	364	117	...	49	5.1
Butte	37,081	224,800	558	169	41	138	4.6
Great Falls	29,928	34,820	456	29	27	35	1.0
NEBRASKA							
Lincoln	81,984	218,650	1,346	458	227	21	5.6
Omaha	223,844	910,000a	3,069	1,064	380	90	4.8
NEVADA							
Reno	21,317	220,000a	1,058	332	85	25	15.6
NEW HAMPSHIRE							
Concord	27,171	72,000	578	314	170	17	11.5
Manchester	77,685	253,296d	1,238	484	117	46	6.2
Nashua	32,927	115,148	572	246	...	8	7.5
NEW JERSEY							
Atlantic City	64,094	1,235,267	697	325	240	132	5.1
Bayonne	79,198	240,416	979	325	86	82	4.1
Belleville	28,167	160,331	422	55	58	24	2.0
Bloomfield	41,623	42,605	628	172	64	23	4.1
Camden	117,536	187,000a	1,379	298	160	93	2.5
Clifton	48,827	342,033	746	87	62	30	1.8
East Orange	68,945	78,524	716	208	104	40	3.0
Elizabeth	109,912	166,983	1,026	329	155	59	3.0
Garfield	28,044	17,445	120	43	24	2	1.5
Hackensack	26,279	113,048	497	120	51	16	4.6
Hoboken	50,115	134,591	893	251	49	53	5.0
Irvington	55,328	172,469	438	193	80	10	3.5
Jersey City	301,173	444,545	2,975	1,379	321	279	4.6
Kearny	39,467	43,000	442	67	71	82	1.7
Linden	24,115	50,182	554	153	64	8	6.3
Maplewood	23,139	8,651	227	111	32	16	4.8
Montclair	39,807	97,291	522	209	63	24	5.3

a. Estimated. c. Building and contents loss only. d. Subject to change.

City	Population (Last Census)	Total Loss 1949	No. Alarms 1949	No. Bldg. Fires 1949	No. Auto Fires 1949	No. Malicious False Alarms 1949	Bldg. Fires Per 1000 Population
NEW JERSEY (Continued)							
Newark	429,760	2,151,923a	4,941	1,916	871	403	4.5
New Brunswick	33,180	173,118	542	143	71	15	4.3
North Bergen Twp.	39,714	76,292	916	133	80	22	3.3
Nutley	21,954	67,478	414	63	31	19	2.9
Orange	35,717	38,425	384	79	40	22	2.2
Passaic	61,394	253,513	645	...	...	49	...
Paterson	139,656	362,770	1,474	770	...	74	5.5
Perth Amboy	41,242	600,000	266	100	56	6	2.4
Plainfield	37,469	75,031	569	147	64	19	3.9
Teaneck Twp.	25,275	47,307	621	88	41	6	3.5
Trenton	124,697	148,503	1,100	494	189	86	4.0
Union City	56,173	690,935	866	220	85	28	3.9
Union Twp.	24,730	135,027	538	100	63	4	4.1
West New York	39,439	133,395	544	91	37	33	2.3
West Orange	25,662	49,530a	331	76	53	5	3.0
Woodridge	27,191	.....	...	...	...	...	...
NEW MEXICO							
Albuquerque	35,449	98,562	644	275	90	86	7.8
Santa Fe	20,325	27,125	174	95	35	3	4.7
NEW YORK							
Albany	130,577	337,619	2,148	662	187	352	5.1
Amsterdam	33,329	188,662	370	141	14	6	4.2
Auburn	35,753	32,783	403	161	46	17	4.5
Binghamton	78,309	316,162	793	250	36	20	3.2
Buffalo	575,901	1,842,799	7,296	1,197	513	205	2.1
Cohoes	21,955	.....	...	...	...	...	...
Elmira	45,106	63,435	446	193	50	11	4.3
Freeport	20,400	.....	...	...	...	...	...
Gloversville	23,329	61,225	317	81	25	5	3.5
Hempstead	20,856	50,365	416	115	47	11	5.5
Jamestown	42,638	38,207	603	150	...	14	3.5
Kingston	28,589	67,708	478	164	58	34	5.7
Lackawana	24,058	156,220	356	53	37	33	2.2
Lockport	24,379	684,005	370	103	45	11	4.2
Middletown	21,908	16,147	237	77	42	6	3.5
Mount Vernon	67,362	161,920	813	228	68	42	3.4
Newburgh	31,883	53,816	278	118	43	14	3.7
New Rochelle	58,408	137,608	588	222	76	21	3.8
New York	7,454,995	20,249,930	61,448	20,449	5,988	10,650	2.7
Niagara Falls	78,029	124,869a	1,027	253	89	44	3.2
North Tonawanda	20,254	35,135	297	82	29	3	4.0
Olean	21,506	42,249	41	69	14	14	3.2
Oswego	22,062	142,802	401	131	30	18	5.9
Port Chester	23,073	.....	...	...	...	...	...
Poughkeepsie	40,478	103,391	463	195	66	35	4.8
Rochester	324,975	727,448	3,548	783	265	102	2.4
Rome	34,214	62,874	492	135	37	37	3.9
Schenectady	87,549	247,596	1,188	326	112	65	3.7
Syracuse	205,967	253,261	1,833	650	264	134	3.2
Troy	70,304	308,140	1,042	...	...	19	...
Utica	100,518	200,456	797	262	236	16	2.6
Watertown	33,385	46,521	458	154	51	22	4.6
White Plains	40,327	137,162	468	123	63	22	3.1
Yonkers	142,598	221,930	2,185	973	173	74	6.8

a. Estimated.

City	Population (Last Census)	Total Loss 1949	No. Alarms 1949	No. Bldg. Fires 1949	No. Auto Fires 1949	No. Malicious False Alarms 1949	Bldg. Fires Per 1000 Population
NORTH CAROLINA							
Asheville	51,310	174,466	730	319	82	61	6.2
Burlington	21,830	.....	...	...	...	...	...
Charlotte	100,899	461,821	1,842	949	300	123	9.5
Durham	60,195	162,571	842	518	103	52	8.6
Gastonia	21,313	26,613	240	101	50	19	4.7
Greensboro	59,319	93,445	887	302	150	89	5.1
High Point	38,495	78,264	530	236	...	49	6.1
Raleigh	46,897	140,406	697	114	83	54	2.4
Rocky Mount	25,568	.....	...	...	...	...	...
Wilmington	47,483	694,681	478	283	51	78	6.0
Winston-Salem	79,815	167,815	772	149	...	54	1.9
NORTH DAKOTA							
Fargo	32,580	111,163	632	205	...	...	6.3
Grand Forks	20,228	207,158	293	177	17	18	8.8
OHIO							
Akron	244,791	463,038	2,472	632	335	283	2.6
Alliance	22,405	512,870	147	141	45	6	6.3
Ashtabula	21,405	55,403	385	81	52	8	3.8
Barberton	24,028	659,180	304	61	38	41	2.5
Canton	108,401	304,271	1,024	236	122	67	2.2
Chillicothe	22,000	20,403	256	52	47	10	2.4
Cincinnati	455,610	646,934	5,172	1,800	761	316	4.0
Cleveland	878,336	3,631,666	8,985	2,435	964	846	2.8
Cleveland Heights	58,000	25,930	880	186	75	16	3.2
Columbus	306,087	799,416	12,197	3,311	703	130	10.8
Cuyahoga Falls	20,546	54,058	342	52	54	17	2.5
Dayton	210,718	274,269	2,595	667	346	233	3.2
East Cleveland	39,495	16,225	305	84	48	8	2.1
East Liverpool	23,555	94,577	402	215	76	12	9.2
Elyria	25,120	33,139	250	93	54	1	3.7
Findlay	20,228	24,245	223	96	...	4	4.8
Hamilton	50,592	89,035	963	243	96	38	4.8
Lakewood	69,160	19,474	293	70	44	36	1.0
Lancaster	21,940	58,283	415	137	49	17	6.3
Lima	44,711	241,637	712	296	110	51	6.6
Lorain	44,125	48,940	529	109	71	42	2.5
Mansfield	37,154	166,972	483	209	106	19	5.6
Marion	30,817	69,156	365	146	56	11	4.7
Massillon	26,644	25,649	335	100	50	15	3.8
Middletown	31,220	115,364	351	161	35	35	5.2
Newark	31,487	111,281	495	149	63	6	4.7
Norwood	34,010	46,437	555	113	45	15	3.3
Portsmouth	40,466	40,958	408	133	101	27	3.3
Sandusky	24,874	39,167	723	134	73	3	5.4
Shaker Heights	23,393	76,360	347	144	...	...	6.2
Springfield	70,662	180,783	1,247	586	117	43	8.3
Steubenville	37,651	257,065	398	141	55	43	3.8
Toledo	282,349	874,005	2,896	960	446	318	3.4
Warren	42,837	287,048	590	101	93	35	2.4
Youngstown	167,720	225,098	1,428	392	184	51	2.3
Zanesville	37,500	19,208	426	182	111	47	4.9
OKLAHOMA							
Enid	28,081	23,383	375	133	47	34	4.7
Muskogee	32,332	111,319	867	218	88	20	6.8
Oklahoma City	204,424	259,915	3,618	589	205	...	2.9
Shawnee	22,053	44,238	317	80	51	9	3.6
Tulsa	142,157	293,390	2,644	813	194	186	5.7

City	Population (Last Census)	Total Loss 1949	No. Alarms 1949	No. Bldg. Fires 1949	No. Auto Fires 1949	No. Malicious False Alarms 1949	Bldg. Fires Per 1000 Population
OREGON							
Eugene	20,838	327,307	1,013	521	336	19	2.5
Portland	363,141	1,126,950	4,986	3,327	352	304	9.2
Salem	30,908	105,846	569	356	52	8	11.5
PENNSYLVANIA							
Abington Twp.	20,857	18,837	73	58	13	...	2.8
Aliquippa	27,023	15,345	192	92	28	4	3.4
Allentown	96,904	61,997	332	212	45	26	2.2
Altoona	80,214	.....	...	...	...	...	...
Bethlehem	58,490	70,273	237	50	49	5	0.9
Butler	24,477	61,185	227	95	53	...	3.9
Chester	59,285	189,848	516	217	62	19	3.7
Dunmore	23,086	.....	...	...	...	...	...
Duquesne	20,693	.....	...	...	...	...	...
Easton	33,589	36,940	162	95	36	7	2.8
Erie	116,955	387,370	1,318	393	147	53	3.4
Harrisburg	83,893	.....	...	...	...	...	...
Haverford Twp.	27,594	.....	...	...	...	...	...
Hazleton	38,009	.....	...	...	...	...	...
Johnstown	66,668	67,723	683	334	157	57	5.0
Kingston	20,679	16,100	129	...	17	5	...
Lancaster	61,345	82,113	294	179	56	24	2.9
Lebanon	27,206	8,925	116	55	14	3	2.0
Lower Merion Twp.	39,566	226,577	560	159	46	2	4.0
McKeesport	55,355	55,930	498	234	72	48	4.2
Monessen	20,257	166,500	94	30	10	4	1.5
Nanticoke	24,387	.....	...	...	...	...	...
New Castle	47,638	159,509	521	355	72	27	7.5
New Kensington	24,055	19,381	107	28	...	37	1.2
Norristown	38,181	18,132	148	34	24	3	0.9
Oil City	20,379	123,373	145	74	38	4	3.6
Philadelphia	1,931,334	5,551,474	16,043	5,282	1,823	1,483	2.7
Pittsburgh	671,659	800,000	5,686	4,515	453	1,011	6.8
Pottstown	20,194	383,661	189	43	2	6	2.1
Pottsville	24,530	98,889	93	48	16	2	2.0
Reading	110,568	.....	...	...	...	...	...
Scranton	140,404	390,000a	1,159	389	246	134	2.8
Sharon	25,622	.....	...	...	...	...	...
Uniontown	21,819	11,431	209	14	24	2	0.6
Upper Darby Twp.	56,883	62,447	428	175	48	6	3.1
Washington	26,166	14,211	211	92	44	10	3.5
Wilkes-Barre	86,236	316,086	538	182	78	54	2.1
Wilkinsburg	29,853	23,289	230	78	43	13	2.6
Williamsport	44,355	77,483	326	201	56	10	4.5
York	56,712	78,692	222	99	...	28	1.8
RHODE ISLAND							
Central Falls	25,121	49,909	313	37	37	15	1.5
Cranston	47,173	75,884	1,112	135	37	22	2.9
East Providence	32,093	27,092	649	113	19	32	3.5
Newport	30,402	71,639	382	226	23	5	7.4
Pawtucket	75,449	147,782	1,321	236	110	69	3.1
Providence	253,214	831,158	3,685	717	125	680	2.8
Warwick Twp.	28,616	144,668	857	157	55	37	5.6
Woonsocket	49,204	87,290c	762	160	87	28	3.3

a. Estimated. c. Building and contents loss only.

City	Population (Last Census)	Total Loss 1949	No. Alarms 1949	No. Bldg. Fires 1949	No. Auto Fires 1949	No. Malicious False Alarms 1949	Bldg. Fires Per 1000 Population
SOUTH CAROLINA							
Charleston	81,347	329,679	767	301	78	92	3.7
Columbia	62,396	160,490	969	192	148	44	3.1
Greenville	34,734	189,784	746	414	120	68	11.9
Spartanburg	32,249	116,169	677	257	115	64	8.0
SOUTH DAKOTA							
Sioux Falls	40,832	79,585	511	215	79	...	5.3
TENNESSEE							
Chattanooga	128,163	263,906c	1,783	575	201	153	4.5
Jackson	24,332	58,258	350	...	28	3	...
Johnson City	25,353	55,130	462	124	50	2	4.9
Knoxville	111,580	240,455	1,730	702	244	89	6.3
Memphis	292,942	765,860	4,576	1,150	580	150	3.9
Nashville	167,402	407,691	2,670	840	291	133	5.0
TEXAS							
Abilene	26,612	205,000	561	56	76	56	2.1
Amarillo	51,686	84,996	1,113	182	195	56	3.5
Austin	87,930	705,485	1,428	294	239	18	3.3
Beaumont	77,335	103,618a	1,050	596	96	88	7.7
Brownsville	22,083	.....	...	...	...	...	...
Corpus Christi	57,301	195,332	909	243	103	79	4.2
Dallas	294,734	1,426,071	6,027	876	684	353	3.0
El Paso	96,810	105,000a	1,172	546	68	115	5.6
Fort Worth	177,662	1,210,893	4,512	1,338	493	303	7.5
Galveston	60,862	76,114	873	326	73	228	5.4
Houston	384,514	1,503,964	4,875	1,782	591	592	4.6
Laredo	39,274	102,637	290	84	27	1	2.1
Lubbock	31,853	138,000	565	...	151	17	...
Port Arthur	56,065	155,436	411	92	49	61	1.6
San Angelo	25,802	58,832	443	97	62	42	3.8
San Antonio	253,854	737,402	3,529	1,106	502	144	4.4
Tyler	28,279	120,076	480	79	...	...	2.8
Waco	55,982	213,441	851	361	147	26	6.5
Wichita Falls	45,112	398,810	702	215	94	49	4.8
UTAH							
Ogden	43,688	51,476	1,240	477	64	32	10.9
Salt Lake City	149,934	1,320,384	1,723	608	180	87	4.1
VERMONT							
Burlington	27,686	.....	569	308	96	66	11.1
VIRGINIA							
Alexandria	49,584	295,000	592	137	101	9	2.8
Arlington County	57,040	126,112	1,134	425	168	36	7.4
Danville	32,749	382,884	345	170	61	14	5.2
Lynchburg	44,541	26,986	709	343	...	55	7.7
Newport News	45,599	124,100	610	322	...	44	7.1
Norfolk	231,949	631,163	2,930	867	235	366	3.7
Petersburg	30,631	110,790	715	640	31	24	20.9
Portsmouth	81,951	.....	...	...	...	...	...
Richmond	222,818	892,401	3,361	1,927	479	186	8.7
Roanoke	69,287	395,412	927	337	73	57	4.9

a. Estimated. c. Building and contents loss only.

City	Population (Last Census)	Total Loss 1949	No. Alarms 1949	No. Bldg. Fires 1949	No. Auto Fires 1949	No. Malicious False Alarms 1949	Bldg. Fires Per 1000 Population
WASHINGTON							
Bellingham	29,314	64,059	832	506	61	23	17.3
Everett	30,224	100,370	755	458	52	14	15.2
Seattle	434,204	764,266	5,392	2,060	476	252	4.7
Spokane	122,001	1,280,430	2,649	1,116	228	102	9.1
Tacoma	129,302	316,352	2,996	1,379	131	212	10.7
Yakima	27,221	59,405	603	299	77	12	11.0
WEST VIRGINIA							
Bluefield	20,641	28,980	179	60	27	...	2.9
Charleston	67,194	819,224	737	278	144	99	4.1
Clarksburg	30,579	34,187	208	87	47	12	2.8
Fairmont	23,105	.....	...	...	...	...	...
Huntington	78,836	346,903	1,071	367	138	96	4.7
Parkersburg	30,103	33,781	233	68	39	5	2.3
Wheeling	61,099	360,322	796	166	89	62	2.7
WISCONSIN							
Appleton	28,436	140,007	512	407	44	30	14.3
Beloit	25,365	379,995a	454	225	43	18	8.9
Eau Claire	30,745	37,249	578	177	58	41	5.8
Fond du Lac	27,209	44,885	488	387	41	17	14.2
Green Bay	46,235	119,144	732	293	37	44	6.3
Janesville	22,992	46,238	437	57	17	13	2.5
Kenosha	48,765	75,455	917	271	81	11	5.5
La Crosse	42,707	115,668	749	424	58	13	9.8
Madison	67,447	122,142	956	299	129	14	2.4
Manitowoc	24,404	29,411	337	133	26	5	5.5
Milwaukee	587,472	1,279,883	8,401	3,295	846	251	5.6
Oshkosh	39,089	68,064	521	243	61	9	6.2
Racine	67,195	245,186	1,456	299	107	47	4.5
Sheboygan	40,638	70,131	459	483	64	9	11.9
Superior	35,136	30,192	605	300	44	25	8.6
Wausau	27,268	118,057	538	319	30	30	11.7
Wauwatosa	27,769	42,153	416	167	24	6	6.0
West Allis	36,364	11,251	612	172	31	6	4.7
WYOMING							
Cheyenne	22,408	130,474	397	124	34	17	5.5
HAWAIIAN ISLANDS							
Honolulu	377,153	960,526	1,349	328	145	160	0.9

1949 FIRE LOSSES, CANADIAN CITIES

ALBERTA							
Calgary	100,044	321,597	981	947	34	132	9.5
Edmonton	113,116	1,497,016	1,389	359	62	105	3.2
BRITISH COLUMBIA							
Burnbay	35,000	211,958	550	253	23	6	7.2
New Westminster	24,000	170,191	522	221	53	16	9.2
Saanich	25,000	37,500	336	63	15	...	2.5
Vancouver	311,800	1,784,231	4,688	4,293	203	120	13.8
Victoria	53,000	91,216	813	575	28	65	10.8

a. Estimated.

City	Population (Last Census)	Total Loss 1949	No. Alarms 1949	No. Bldg. Fires 1949	No. Auto Fires 1949	No. Malicious False Alarms 1949	Bldg. Fires Per 1000 Population
MANITOBA							
St. Boniface	21,613	29,475	313	163	16	22	7.6
Winnipeg	229,045	478,290	2,367	809	76	289	3.5
NEW BRUNSWICK							
Moncton	22,763	55,924	388	215	15	16	9.4
Saint John	57,741	322,436	1,137	392	9	69	7.6
NOVA SCOTIA							
Glace Bay	25,147	32,000	119	90	4	4	3.6
Halifax	106,742	323,016	1,188	917	36	108	8.6
Sydney	28,305	.....	...	...	...	...	...
ONTARIO							
Brantford	34,848	73,972	573	339	46	11	9.7
East York Twp.	43,399	59,450	369	73	22	9	1.7
Fort William	29,103	46,962	483	52	1	22	1.8
Guelph	23,273	18,946	352	20	...	...	0.9
Hamilton	175,364	697,684	1,931	572	189	140	3.3
Kingston	33,296	65,188	567	320	47	53	9.6
Kitchener	36,797	67,726	286	77	2	4	2.1
London	81,158	159,356	805	271	75	14	3.3
North York Twp.	26,000	120,214	603	164	43	25	6.3
Oshawa	26,856	100,149	360	231	31	23	8.6
Ottawa	195,327	534,333	1,819	855	144	174	4.4
Peterboro	32,379	42,251	669	143	59	60	4.4
Port Arthur	25,100	39,250	475	257	28	13	10.2
St. Catharines	34,559	.....	...	...	...	...	...
Sarnia	20,082	42,330	207	25	37	16	1.2
Sault Ste. Marie	28,813	194,305	287	178	13	17	6.2
Scarboro Twp.	24,142	96,200	528	74	24	34	3.1
Sudbury	35,812	178,124	535	114	15	...	3.2
Timmins	24,070	33,973	504	354	17	8	14.7
Toronto	745,626	3,000,000	6,390	3,549	545	642	4.8
Windsor	108,567	240,673	1,051	492	95	138	4.5
York Twp.	80,348	50,755	647	440	47	16	5.5
QUEBEC							
Chicoutimi	20,103	.....	...	...	...	...	...
Hull	36,900	119,427	797	543	19	53	14.7
Jonquiere	21,500	66,611	430	343	3	38	15.9
Lachine	27,104	320,686	301	51	13	47	1.9
Montreal	983,000	4,430,443	10,359	2,106	495	2,706	2.1
Outremont	31,400	69,053	245	38	9	29	1.2
Quebec	176,386	1,389,481	2,835	2,032	80	577	11.5
Shawinigan Falls	23,868	73,034	239	161	7	21	6.7
Sherbrooke	38,942	52,390	692	103	31	32	2.6
Three Rivers	46,000	149,381	440	280	20	21	6.1
Verdun	74,080	174,470	758	503	26	76	6.8
Westmount	25,328	24,798	278	64	15	32	2.5
SASKATCHEWAN							
Moose Jaw	23,069	114,601	342	156	8	33	6.8
Regina	60,246	807,100	798	347	38	99	5.8
Saskatoon	46,028	96,001	562	362	19	10	7.9

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Insurable values of properties protected	$15,157,491,000
Ratio of losses to insurable values protected	3/100ths of 1%
Fire loss immunity in 1949	$99\frac{97}{100}\%$

AVERAGE FIRE LOSS IMMUNITY DURING THE PAST TEN YEARS $99\frac{96}{100}\%$

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Waterflow alarms, caused by fires or serious leaks	2,883
Manual fire alarms	112
Insurable values of properties protected	$8,572,030,000
Ratio of losses to insurable values protected	2/100ths of 1%
Fire loss immunity in 1949	$99\frac{98}{100}\%$

AVERAGE FIRE LOSS IMMUNITY DURING THE PAST TEN YEARS $99\frac{98}{100}\%$

These figures reflect the importance of continuous supervision, regular inspections and tests and proper maintenance. Such specialized attention is essential to dependable protection service.

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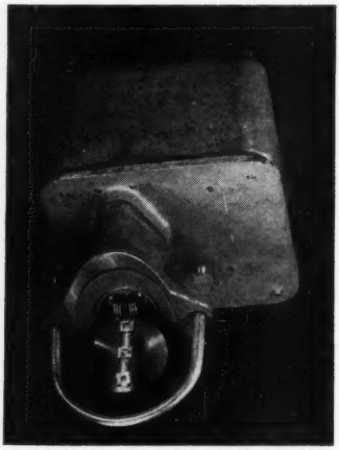

3-inch size shown above. To install simply drill hole in pipe.

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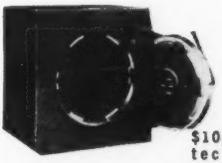

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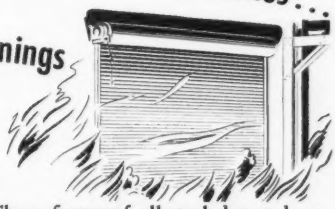

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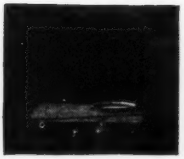
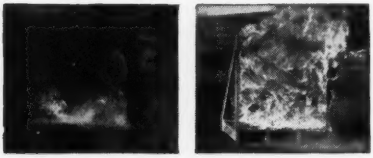
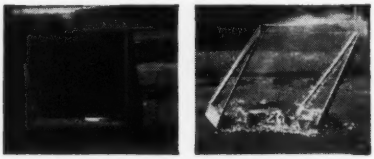


Test structures built of Koppers fire-retardant wood (left) and untreated wood (right) ready for the fire test. Five quarts of kerosene, placed in pans, furnishes fuel for each blaze.



Both structures are quickly enveloped in flame. Treated structure resists fire, but untreated one encourages it, contributes fuel to the fire.



After twenty-two minutes the untreated structure, still burning, is collapsing. Note that in the treated structure, the fire stopped when the fuel burned out.

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Right · The treated structure was charred . . . but retained its integrity and strength, as the 800 pound load shows.

Left · Continued burning reduced the untreated structure to ashes.

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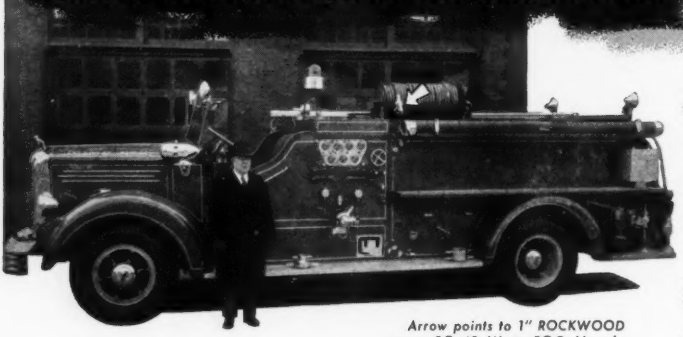

Arrow points to 1" ROCKWOOD type SG-48 WaterFOG Nozzle

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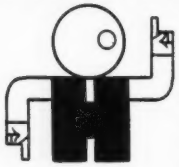

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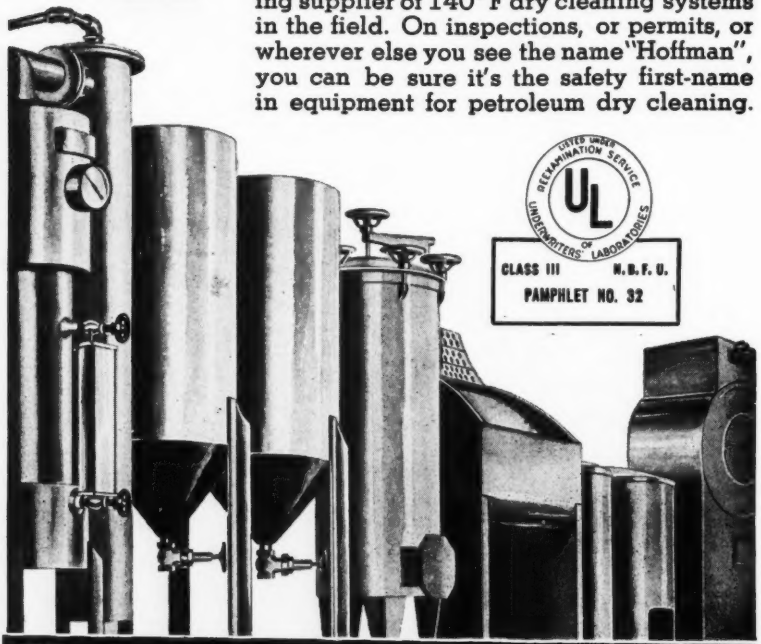

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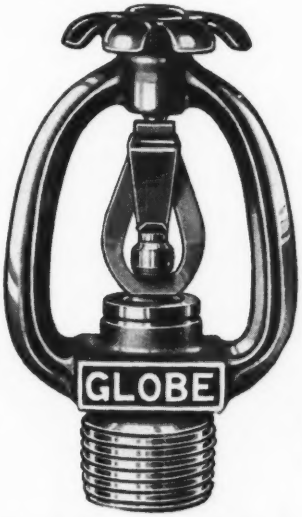

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The Saveall Sprinkler is primarily an ornamental balanced design and when desired can be furnished Brass or Chrome, polished or satin finish, in all temperature ratings.

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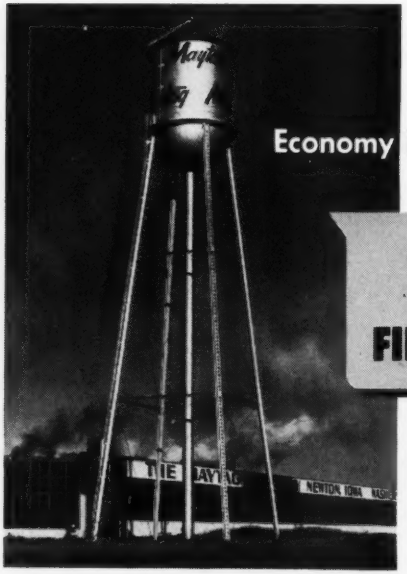

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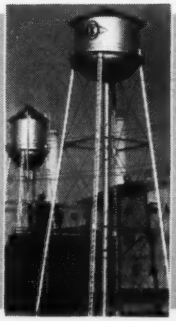

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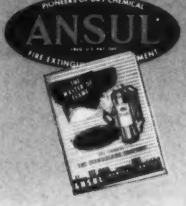
FIRE PROTECTION by the dry chemical method has proved *Most Effective* as well as *Most Economical*. And only Ansul offers a complete line of hand, wheeled and stationary dry chemical fire extinguishers. Investigate Ansul Piped Systems for protection of special hazards.

Send for File No. 513. You will receive a variety of helpful printed matter. Included is our latest catalog which describes Ansul Extinguishers of all sizes — from the small Ansul Model 4 to Ansul Piped Systems and Ansul 2000 lb. Stationary Units.



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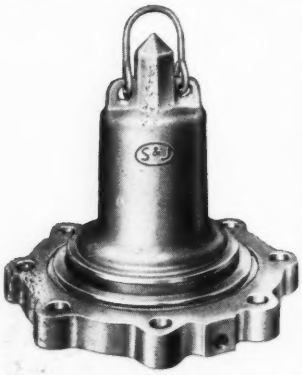
ANSUL CHEMICAL COMPANY
FIRE EXTINGUISHER DIVISION, MARINETTE, WISCONSIN
DISTRIBUTORS IN PRINCIPAL CITIES IN THE UNITED STATES, CANADA, AND OTHER COUNTRIES

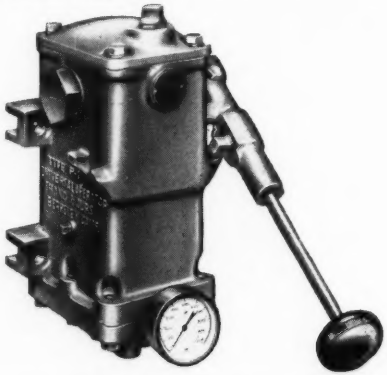
DON'T BE HALF SAFE!



S. & J. Hydraulic Safety Valves can be opened only by hydraulic pressure, and are normally held closed under spring tension.

It never pays to compromise with SAFETY. If safety is a prime consideration, it is always wise to go all the way. Consider the Internal Safety Valves which are installed inside the tank compartments of petroleum delivery trucks. Those operated with hydraulic pressure embody the MAXIMUM IN SAFETY because hydraulic pressure is POSITIVE. You either have it, or you have lost it. If an accident ruptures a hydraulic line, or the melting of a fusible plug releases the pressure, the hydraulic safety valves which are held closed under spring tension, cannot be opened until hydraulic pressure is restored. Valves operated by cables which stretch, or rods which bend, are only **half safe,** because an accident to the operating mechanism often opens a normally closed valve. Think that over!

Small fusible plugs, installed in the copper tubing hydraulic lines, melts at 165°F. If a fire occurs during unloading operations, the melting of a fusible plug releases the hydraulic pressure and the valves close instantly.



Several strokes of the handle of the hydraulic operator shown at the right are required to open S. & J. Safety Valves. They cannot be opened accidentally.

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(Based on 100 for untreated red oak)
FIRE SPREAD . . . . . 10 - 20
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Fiberglas* Coated Duct Insulation has it!

Listing by the Underwriters' Laboratories, Inc. is another *first* for Fiberglas Coated Duct Insulation. Based on their tests it is now universally accepted by insurance interests as a *fire retardant* material . . . also *no panic hazard,* no toxic fumes because smoke developed is negligible.

To rating engineers this means *impartial* assurance that the use of Fiberglas Duct Insulation, especially in concealed spaces, provides greater fire protection . . . more lasting protection because of the natural properties of the basic material, ageless fibers of glass. OWENS-CORNING FIBERGLAS CORPORATION, Dept. 117-D, Toledo 1, Ohio.

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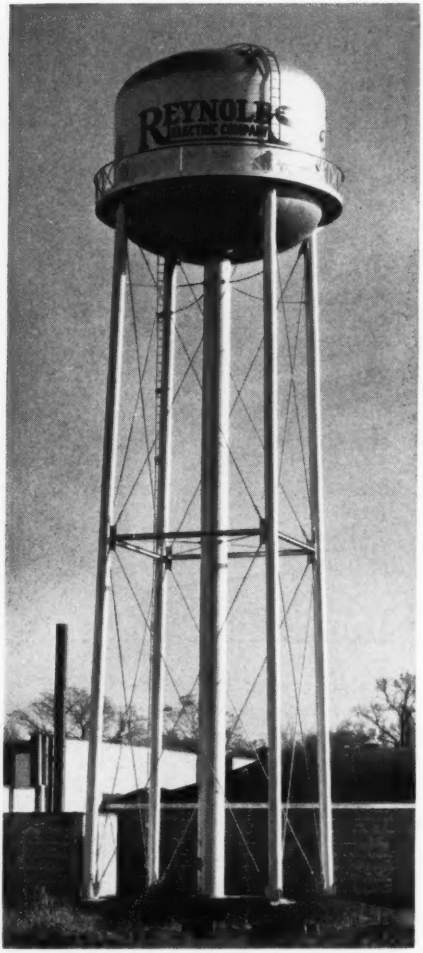
PROTECTS NEW PLANT



at River Grove

This 60,000-gallon elevated steel tank maintains gravity water pressure in the automatic sprinkler system at the Reynolds Electric Company's new plant at River Grove, Ill.

The new Reynolds plant is a modern, new one-story building containing about 50,000 sq. ft. of floor space. The entire plant is protected by an automatic sprinkler system with 600 sprinkler heads.

The elevated tank, which is 60 ft. to the bottom, provides the primary water supply for the fire protection system, and the village water system is used as a secondary source. According to estimated insurance costs, the tank will pay for itself through premium savings in approximately 12 years.

Write our nearest office for quotation on tank installations. State capacity, height to bottom and location.

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The Tenth Edition of the "N.F.P.A. Handbook of Fire Protection" was published two years ago, and in that time more than 15,000 copies have been sold. This exceeds all previous records for the sale of this well-known reference book and attests to its broad usefulness.

Tremendous advances in fire protection have been made in every branch of the fire engineering field since the Ninth Edition of the Handbook in 1941. The Tenth Edition contains new and up-to-date information, a good deal of which represents developments that were made during the war — in industry, in fire prevention and in fire extinguishment.

The Handbook is the basis of education for beginners in the fields of fire protection and fire prevention, and is the constant companion of experienced men specializing in these fields. It is an invaluable reference work for those occasionally requiring specific facts of this character. In keeping with the purpose of a reference book, all information is presented clearly, concisely and as far as possible in non-technical language.

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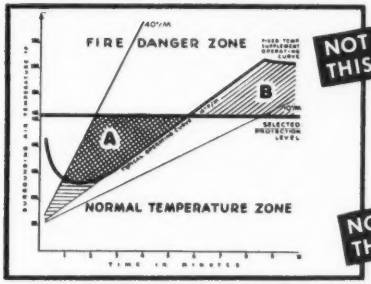
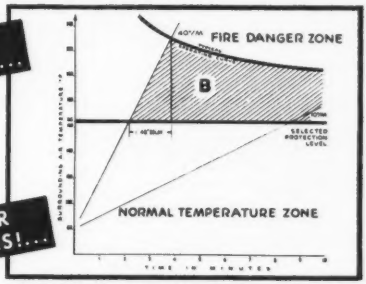
DETECT-A-FIRE operates on the exclusive Fenwal principle. Activating element is the *single-metal*, temperature-sensitive shell which, in direct contact with the air, reacts without lag. Approved by Factory Mutual Laboratories, listed by Underwriters' Laboratories, Inc., for ordinary and hazardous locations Class I, Groups C and D; Class II, Groups E, F and G for 25′ spacing.



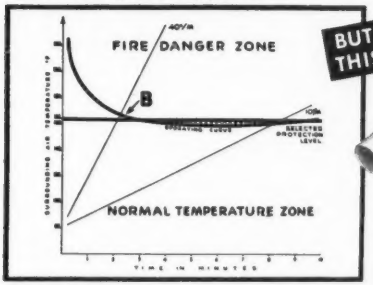
RATE-OF-RISE DETECTOR has dangerous false alarm zone (a), and unprotected zone (b), even with fixed-temperature supplement.

NOT THIS!...

NOR THIS!...

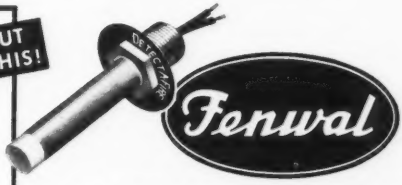


FIXED-TEMPERATURE DETECTOR permits wide unprotected zone (b), due to thermal lag.



DETECT-A-FIRE'S instant response leaves only negligible unprotected zone (b), eliminates false-alarming.

BUT THIS!



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SENSITIVE . . . *but only to heat*

FREE bulletin gives you complete details on amazing Detect-A-Fire. See how you, too, can improve your fire alarm and extinguishing systems. Just mail coupon.

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STREET.....

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Temperature Control Engineers

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Considered to be one of the foremost recent advancements in the science of fire protection, *Automatic* AER-O-FOAM has opened new avenues in fire safety which heretofore were not thought to be practical or economically feasible. Hazardous conditions familiar to chemical processing industries, metal working plants, petroleum storage and handling, electric power generation, and other occupancies where flammable liquids are involved, can now be fully safeguarded by engineered *Automatic* AER-O-FOAM protection.

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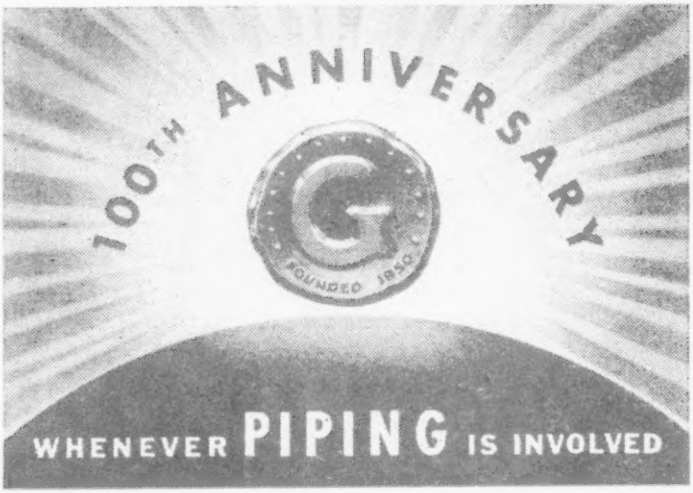

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Today, there is a type of Grinnell System to meet practically every fire protection need. Complete information relative to their application to any particular risk is available for the asking from any of our offices throughout the country. Grinnell Company, Inc., Providence 1, R. I.

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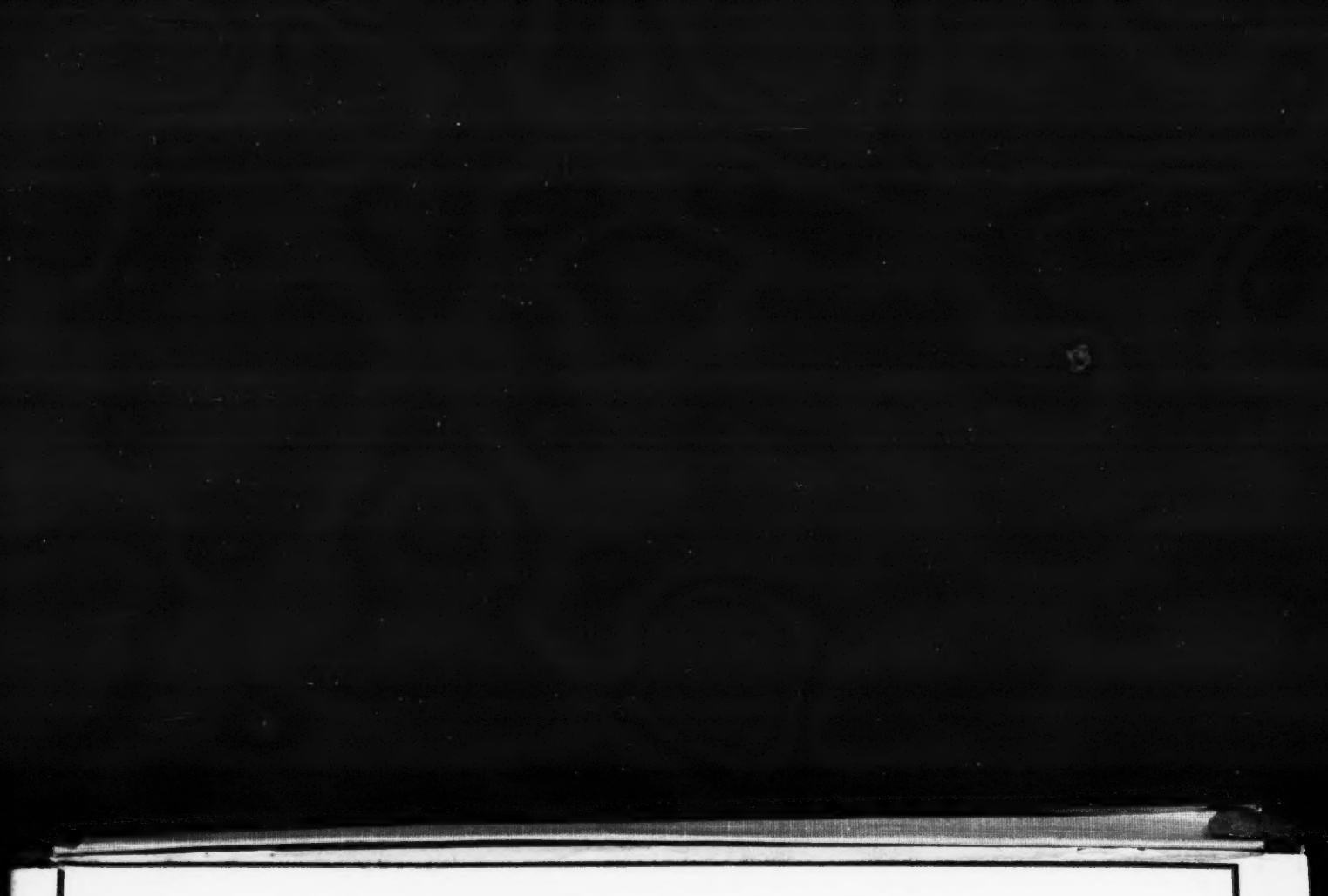
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